The Allen Consulting Group

Sustainable Energy Jobs Report

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Prepared for the Sustainable Energy Development Authority

The Allen Consulting Group

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Table of Contents

Preface

The Allen Consulting Group was commissioned by SEDA to analyse the impact of sustainable energy opportunities on jobs in NSW. A Steering Committee was established by SEDA to oversee the preparation of the report. In addition to SEDA representatives, members of the Committee included the:

- Australian Workers' Union;
- Construction Forestry Mining & Energy Union;
- Electrical Trades Union;
- Transport Workers Union;
- Labor Council;
- Department of State and Regional Development;
- Country Energy;
- ANZ Infrastructure Services; and
- Australian Business Ltd.

The Terms of Reference for this Report were agreed in consultation with the Steering Committee.

Around the world, energy markets are beginning to respond to the risk of climate change through both voluntary and regulated measures. Although the cost of renewable sources of energy is not yet competitive with conventional, carbon-intensive alternatives, a clear downward pressure on costs for wind, solar, and biomass has been identified. At the same time, significant opportunities exist to address energy supply pressure by managing down demand. Demand management offers positive investment returns, but take-up is limited due to information and other barriers.

Australian governments are likely to continue to promote greenhouse gas emission reductions and increases in renewable energy sources. Like in any other competitive market, those states positioned with the most experience in lowest cost technologies, will have the best chance of attracting investment and jobs. To lead in competitiveness in sustainable energy technologies, NSW needs to promote demand management and renewable technologies so that the NSW sustainable energy industry ("SEI") can progress down its various learning curves ahead of other States. Already, Victoria and South Australia are developing an advantage in wind and Queensland has a clear advantage in biomass. But these are early days in SEI development and long-term competitiveness is not yet determined.

A number of scenarios have been modelled in the report that reflect the kind of policies that could deliver an SEI competitive advantage and new energy sector jobs for NSW. As the many case studies included in this report indicate, there are numerous examples of successful similar initiatives around the world.

The challenge for NSW is to continue to support the sustainable energy industry in order to maintain the State's competitiveness in this dynamic and rapidly growing industry. The outcomes of the modelling undertaken as part of this report indicate that, to promote the competitiveness of the SEI and support SEI investment and jobs, it is necessary to attack the barriers to market development and facilitate the move by new technologies down their learning and cost curves.

Abbreviations

ABARE	Australian Bureau of Agriculture and resource Economics
ABS	Australian Bureau of Statistics
AC	Alternating Current
ACCC	Australian Competition and Consumer Commission
ACT	Australian Capital Territory
AD	Anaerobic Digestion
AEA	Australian EcoGeneration Association
AGL	Australian gas Light Company
AGO	Australian Greenhouse Office
ANZSIC	Australian and New Zealand Standard industrial Classification
AUS	Australia
AusWEA	Australian Wind Energy Association
BAU	Business as usual
BIPV	Building Integrated photovoltaic
CBM	Coal bed methane
CCP	Cities of Climate Protection
CH_4	Methane
CHP	Combined Heat and Power
C&I	Commercial and Industrial
c/kWh	cents per kilo-Watt hour
CLF	Conservation Law Foundation
CMM	Coal Mine Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide equivalent

CoPS	Centre of Policy Studies
COP	UNFCCC Conference of the Parties
CPI	Consumer Price index
CRESTA	Centre for Renewable Energy Systems Technology Australia
CSIRO	Commonwealth Scientific & Industrial Research Organisation
DC	Direct Current
DISR	Department of Industry, Science and Resource
DM	Demand Management
DOE	Department of Energy (United States of America)
DSM	Demand Side Management
EMR	Energy market Reform
EPA Vic	Environmental Protection Authority Victoria
ESAA	Electricity Supply Association of Australia
ESB	Energy Smart Business
ECU/kWh	Electrical Conversion Unit per kilo Watt hour
FERC	Federal Energy Regulatory Commission
GWh pa	Giga Watt hour per annum
GCP	Greenhouse Challenge Program
GDP	Gross Domestic Product
GE	General Equilibrium
GGAP	Greenhouse Gas Abatement Program
GHG	Greenhouse Gas
GSE	Granite State Electricity
GSP	Gross State Product
GWp	Gigawatts peak
HDI	Household Disposable Income
IEA	International Energy Agency

IO	input-output
IPART	Independent Pricing and Regulatory Tribunal
IRP	Integrated Resource Planning
ISR	Industry Science and Resource
kW	kilo Watt
LFG	Landfill gas
LPG	Liquefied Petroleum Gas
LUCF	Land Use Change and Forestry
MEPS	Minimum Energy Performance Standards
METI	Ministry of Economic, Trade and Industry
MG&E Model	Madison Gas and Electricity
MMRF Model	MONASH Multi-regional Forecasting Model
MMR	MONASH Multi-regional
MRET	Mandatory Renewable Energy Targets
mph	miles per hour
Mt	Mega tonnes
Mtoe	Million tonnes oil equivalent
Mt/y	Mega tonnes per year
MW	Mega Watt
NE	Narragansett Electric
NECA	National Electricity Code Administrator
NEES	New England Electric System
NEMMCO	National Electricity Market Management Company
NFFO	Non-Fossil Fuel Obligation
NO_x	Oxides of Nitrogen
NSW	New South Wales
NT	Northern Territory

OECD	Organisation for Economic Cooperation development
p/kWh	pence per kilo Watt hour
PSC	Public Service Commission
PV	Photovoltaic
PVRP	Photovoltaic Rebate Program
Qld	Queensland
RAS	Return Active Sludge
RD&D	Research, Development and Demonstration
R&D	Research and Development
RE	Renewable Energy
RECP	Renewable Energy Commercialisation Program
REIP	Renewable Energy Industry program
RRPGP	Renewable Remote Power Generation Program
SA	South Australia
SEDA	Sustainable Energy Development Authority
SEI	Sustainable Energy Industry
$m pa	Millions of dollars per annum
SMUD	Sacramento Municipal Utility Districts
STE	Solar Thermal Electricity
STI	Sustainable Technologies International
SO_x	Sodium Oxides
TAFE	Technical and Further Education
Tas	Tasmania
TPES	Total Primary Energy Supply
TWh	Tera Watt hour
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change

UNSW	University of New South Wales
US	United States of America
VAM	Vent Air Methane
Vic	Victoria
WA	Western Australia
Wh	Watt hour
WLC	WindLite Corporation
Yen/w	Yen per week

Units

J	joules
L	litres
t	tonnes
g	grams
Wh	watt-hours
b	billion, used in money quantities ($b)
m	million, used in money quantities ($m)

Standard metric prefixes

kilo (k)	10^3 (thousand)
mega (M)	10^6 (million)
Giga (G)	10^9 (1,000 million)
Tera (T)	10^{12}
Peta (P)	10^{15}
Exa (E)	10^{18}

Standard conversions

1 barrel	= 158.987 L
1 kWh	= 3,600 kJ
I PJ	= 277.8 GWh

Executive Summary

The Allen Consulting Group is pleased to provide this *Sustainable Energy Jobs Report* to the Sustainable Energy Development Authority (SEDA).

The major goals of the study are to:

- review the Sustainable Energy Industry (SEI) and identify key sustainable energy technologies and policies;
- assess the potential of the SEI to contribute to the NSW economy and, in particular, to grow job numbers;
- develop scenarios for the SEI of the future; and
- outline strategies to realise the potential for job growth identified through the above process.

In doing so the study is to have regard to factors including:

- the United Nations Framework Convention on Climate Change and the Kyoto Protocol;
- global and regional growth in energy demand;
- approaches to promote sustainable energy adopted by overseas governments; and
- measures in Australia to promote renewable energy.

Understanding the scope of the study also includes what it is not supposed to do. The study is not an analysis of the various means to achieve greenhouse gas abatement, or an evaluation of the costs and benefits of greenhouse gas abatement. While intending that the report take existing policy measures such as the Commonwealth Government's Mandatory Renewable Energy Target into consideration, the study is not intended to provide an evaluation of those measures. For the above reasons the study also does not examine the recently introduced NSW enforceable greenhouse benchmarks scheme for electricity retailers, and does not model benchmark scheme outcomes because the terms of the scheme were not finalised when we conducted our analysis.

ES.1 World Energy Supply and Demand

A good starting point is to begin with the global picture. A key message from analysis of current global energy supply and current forecasts over the period 1971 to 2030, is the limited outlook for the SEI in general and renewables specifically in the absence of government intervention in the energy market. Outcomes in the global energy situation to date and in prospect reflect market failure and other difficulties that block the development of the SEI and renewable energy.

Nevertheless governments around the world are taking unilateral and multilateral action to address widespread concerns about the sustainability of unadjusted energy market outcomes. While many countries are still giving consideration to broad measures to address the threat of climate change posed by greenhouse gas emissions, a large number have already implemented policies intended to give renewable energy a foothold in energy markets. Given the cost differential against renewable energy technologies that prevails at present, this is a more expensive approach than allowing market forces to play out fully.

Governments in many countries appear to be acting on the basis of maintaining a range of energy market options as a means of managing risk and uncertainty about the future and they appear to essentially view the additional costs as the equivalent of an insurance premium. Key factors may include uncertainty about the value of abating pollution, particularly the long term cost of greenhouse gas abatement and the cost of carbon, with the expectation that these costs will rise over time. Recognising the importance of access to reliable energy supplies for the smooth functioning of modern economies, governments also appear to be acting to ensure that their economy has familiarity with as wide a range of energy technology options as possible. It appears that they wish to avoid a loss of competitiveness that may result from reliance on the lowest cost energy technology if that technology is blocked in future. Some governments also appear to view the present cost of support for SEI technologies and renewable electricity generation as a means of ensuring long run energy competitiveness.

There is also growing recognition of the potential of the sustainable energy industry to grow jobs and facilitate access to rapidly growing export markets. Countries such as Denmark and Germany, for example, now dominate the global wind market due to the effect of industry support measures implemented domestically. There is also growing recognition of sustainable energy's broad environmental benefits – for example China is actively pursuing wind energy in order to avoid the regional air quality impacts associated with conventional energy supply.

Forecasts in relation to renewable energy demand and supply are therefore likely to be revised up as these policies take root.

Reflecting the likelihood of continued and expanded policy support for the SEI and given sustained growth in overall global energy demand, there is likely to be SEI export and investment opportunities for jurisdictions and companies that establish a technological lead in SEI technologies. This may also apply for Australia and NSW given close proximity to the Asia Pacific region which, despite current uncertainties, is widely expected to resume its rapid development trajectory.

ES.2 Australian Energy Supply and Demand

Projections for energy supply and demand in Australia are not dissimilar to those for the world as a whole in terms of the relatively limited share of renewable energy in total energy or electricity supply without government support and policy intervention.

Reflecting the impact of recent policy measures, particularly the introduction of the Mandated Renewable Energy Target (MRET) established by the Commonwealth Government, recent growth rates for renewables have been high. Because this growth is off such a low base, non-hydro renewables are still only projected to supply 3.6 percent of Australian electricity generation in the very long run (ie, 2020) with current policy settings. Nevertheless, clusters of expertise and scale are beginning to form in different states, with most progress expected for biomass and wind. Biogas also is expected to grow more rapidly than the electricity supply industry at large.

The key message is that, in the absence of mechanisms through which negative environmental externalities associated with fossil fuel generation get fully factored into its price, renewables will not significantly increase their share of domestic energy supplies at this time and into the medium term without government intervention.

Against this background, opportunities for development of the SEI industry are likely to be shaped by policy initiatives in jurisdictions seeking to engage in the SEI. Recognising the potential of the SEI, other countries and Australian States are moving ahead of NSW in a number of relevant areas. Arguably, there is a limited window of opportunity for NSW, if it chooses, to implement additional measures to further develop the sustainable energy industry in NSW.

ES.3 SEI Competitiveness

Renewable electricity supply and the sustainable energy industry in general face significant challenges to competitiveness at present reflecting market failure, regulatory failure and infant industry cost structures. As a result, renewable electricity is currently more expensive than traditional supply options in most instances.

The available evidence based on studies from abroad and in regard to the situation in Australia suggests that the competitiveness gap varies by SEI technology and in many cases the location of that technology. Biomass and biogas are often seen as being close to competitive with large-scale traditional fossil fuel technologies. However, these technologies are currently limited in terms of scope for additional applications on an economic basis.

Wind powered electricity generation is seen by many analysts as moving closer to competitiveness. The available data points to rapid cost reductions in renewable energy options as they progress from fairly experimental approaches to more developed commercial projects. Wind has seen a very significant reduction in cost to the point that it is competitive with a traditional renewable technology – small scale hydro electricity generation. The prospect that interests many analysts is that wind generation costs appear to be continuing to fall. There is also considerably more scope to deploy wind power than hydro (particularly in a dry flat continent such as Australia) with fewer environmental complications.

While the gap is closing, support for the renewable electricity supply activity is likely to impose a cost upon the community. An economic justification for bearing such costs would have regard to the lead times involved in gaining experience in the sustainable energy industry – implying an 'insurance' aspect. Governments that have implemented industry development measures in support of renewable energy also cite the benefits of a more diverse and secure supply system, regional job growth, export opportunities, and lower unit costs through 'learning by doing' and economies of scale. Governments also recognise renewable energy's longer term role in addressing potential carbon constraints.

The study looks at how transition costs associated with developing the sustainable energy industry could be mitigated through concerted policy action involving a mixture of renewable energy and demand management approaches and other measures.

ES.4 The Development of Sustainable Energy Technologies

There is evidence that there is an emerging path to competitiveness and commercial viability for various SEI technologies in Australia and in NSW.

Seven sustainable energy technologies have been analysed in detailed case studies in the body of the report. Key observations about the development of each are as follows:

Commercial — industrial energy efficiency. Improving the energy usage practices of industry, the efficiency of appliances used by industry and the energy efficiency of buildings can enhance sustainability indicated through reduced greenhouse gas emissions and avoided economic costs. In general, Australia currently lags behind world's best practice in this field and currently has limited capacity in terms of manufacturing of related equipment and in the provision of energy efficiency services. This shortfall also creates an opportunity. Experience overseas and in Australia suggests that supportive government policies may be useful in building capacity and momentum to place the activity onto a commercial footing.

Industry — small cogeneration. Thermal efficiency can be raised from an average of around 30 percent for traditional gas power stations up to around 85 percent in smaller scale cogeneration facilities. The greenhouse gas savings and economic savings can be commensurate with the energy efficiency gains. The application of these technologies is limited to specific industrial sites, although it is considered that the potential market for the technology could rise from about 5 percent of stationary energy needs currently supplied to about 10 percent. A supportive policy environment is needed in order to offset identified market and regulatory failures.

Dry agricultural wastes. Utilising these wastes as a source of energy opens up the opportunity to solve current problems with their disposal, reduce pollutants (including reductions in GHG) and raise the viability of industry. The activity requires policy support in order to facilitate various permits and approvals for new industrial activity and to demonstrate the viability of such investments.

Wind power. This technology presents the opportunity to create 'clean', renewable electricity. Emerging evidence indicates that wind power costs are falling with practical experience, although the rate of cost improvement is slowing down. While many of the component parts of wind turbines are manufactured overseas, major value added components are domestically sourced including design and implementation. Obtaining community support and approval is a major factor. Areas in NSW (including in the great dividing range) have been found to sustain strong wind speeds comparable to coastal sites in southern Australia. Despite the availability of the key resource, and proximity to a large customer base, NSW is not at the forefront of wind power development at present. Current market forecasts place other states in a position of more rapid growth.

Solar photovoltaic (PV). Solar energy provides a further opportunity to produce clean, renewable electricity. Even though the technology is still developing (ie, it is still relatively expensive), global demand for solar electric systems is growing rapidly. The Australian PV market is dominated by remote area applications where PV displaces small diesel powered plants or where other sources suffer problems with reliability. Major producers of this technology are located in NSW. Considerable research and development activity is underway (including at leading sites in NSW) which, combined with economies of scale in production, are expected to sustain a long run trend towards cost competitiveness.

Waste Coal Mine Gas and vent air technology. Waste Coal Mine Gas (WCMG) technologies intercept fugitive pollutants and GHG emissions from active and abandoned mines and convert them into a useful energy source. Current technologies have the potential to utilise up to 95 percent of WCMG. Industry is beginning to factor in this potential into commercial operations with significant funding support from Commonwealth and state governments. Australians (including experts in NSW) appear to have a leading position in this field at present and there appears to be potential for the export of services to countries in the Pacific region.

Bio Diesel. The use of waste products to produce bio diesel has the potential to reduce greenhouse gas emissions by between 70 to 90 percent depending on the feedstock. Currently the market is on a very small scale and most bio diesel is sold at a premium as a ‘green’ fuel. It appears that the potential for growth and the financial viability of producers will be shaped by tax treatment. The fuel (at 100 percent bio diesel) is currently not subject to excise however this is not the case for blends with mineral diesel Additionally, the federal government rebates available to other mineral diesel and bio fuels such as ethanol are not available to bio diesel.

Analysis of these technologies gives support to the notion of economic gains from ‘learning by doing’. Basically, costs in some approaches fall as the practical issues and wrinkles are ironed out.

The SEI technology case studies also illustrate the role played by supportive public policy. Even in areas characterised by almost immediate commercial returns, such as in mine gas waste utilisation, development and commercialisation of SEI technologies have been associated with government support. Policies seem to signal change, or flag that change is needed, as well as provide funding that builds leverage and momentum for change.

Other areas of SEI technology development are not competitive on a widespread basis without public policy intervention. Recognition of this is driving the intervention by governments in many energy market areas. The Commonwealth’s MRET scheme was established with the specific intention of providing industry development support to the renewable electricity generation sector and encourage learning in respect of the establishment and operation of renewable technologies.

Given an element of learning by doing, late followers may face higher costs, and this could form a barrier to entry.

ES.5 Demand Management (DM) Drivers

Traditionally growing energy needs have been met with a supply side response with ‘build and generate’ options. In contrast, Demand Management (DM) approaches involve investments that lead to reduced or changed patterns of energy demand. The focus here is upon DM actions that enhance sustainability in terms of producing returns from reduced environmental impacts and enhanced economic efficiency.

Studies about DM in Australia and overseas consistently indicate average commercial rates of return on DM investments of over 20 percent. DM has the potential to drive material efficiencies in the NSW economy. Large companies applying energy efficiency technologies in NSW are already achieving attractive rates of return, and network level initiatives could also replace capital expenditure at a time when generation and network constraints are becoming increasingly apparent.

Aggressive implementation of DM could deliver an efficiency dividend that enables households and businesses to reinvest energy savings, creating jobs in the process (both within the sustainable energy industry and across the economy). Employment in the energy efficiency sector currently accounts for 70 percent of the jobs in the SEI. The DM industry (manufacturing, transport, installation, maintenance) would offer strong job potential if stimulated.

The calculations of commercial returns generally do not include a value for environmental gains including potential greenhouse gas savings. Including broader social and environmental values would enhance estimates of the overall gains.

Given the high rates of return from DM investments the key question is what is preventing more vigorous DM investment? The answer is not entirely clear, but it seems that a range of factors are at play including information, institutional and regulatory barriers. Many of the same regulatory barriers impact upon DM as upon renewable energy options that also involve savings in terms of avoided electricity network augmentation. This points again to a need for supportive public policy.

ES.6 Economy Wide Evaluation

What is the potential contribution of the SEI to output and employment in NSW? How would the outlook change given likely or possible policy measures?

To answer these questions the consultancy team has used the Monash Multi-Region Forecasting Green Model (MMRF-Green). This is a multi-sector dynamic model of the Australian economy covering the six states (specifically identifying NSW) and two territories. Using MMRF-Green permits evaluation of economy wide changes, including outcomes for government budgets, specific industries and implications for employment. It also allows assessment of implications for greenhouse gas emissions. It does all of this simultaneously within a consistent framework.

Taking the economy wide perspective is important when assessing changes in the energy sector and progress in adopting more sustainable energy outcomes. Changes in this sector can impact on almost every industry, they can shape competitiveness in many of Australia’s export activities, can alter government budgets, reflecting public ownership of many energy assets and the composition of the tax base, and will ultimately impact on households, including through the fact that energy is a noticeable part of every Australian household’s expenditure.

MMRF-Green has been used to model a limited number of policy approaches designed to illustrate the impact of core policy options that could be adopted to advance development of the SEI in NSW. Scenarios include:

- *Demand Management Measures (Scenario Three).* This scenario assumes the successful implementation of a range of demand management activities in the industrial, commercial and residential sectors over a five-year period which, at full implementation, represents a reduction in electricity demand of 1070 MW. The analysis models a scenario that is unlikely to eventuate without supportive policy measures to overcome information/institutional barriers and encourage adoption of these measures.

- *Expansion of the Mandatory Renewable Energy Target (MRET) (Scenario Four).* This scenario is based on an expanded mandatory target of 19,000 GWh of additional renewable energy generation by 2010, which is broadly equivalent to the '5 percent' renewable energy target recently proposed by some industry stakeholders.[1]

- *Policy Measures to Expand the NSW SEI (Scenario Five).* This scenario is based on the establishment of a leveraged fund to promote the SEI in NSW. This could be undertaken through a range of measures to promote investment in renewable energy generation and/or DM.

These policy scenarios are compared against base case scenarios including:

- *Baseline (no measures) Projection (Scenario One).* This scenario assumes that no government measures and policies or voluntary industry activities are specifically undertaken to reduce greenhouse gas emissions in response to global warming. It also does not take account of the energy market reform (EMR) that commenced in the early 1990s.

- *Baseline (with measures) Projection (Scenario Two).* This scenario takes into account the impact of the range of supply and demand side measures aimed at reducing greenhouse gas emissions and of recent energy market reform (EMR) that are currently in place.

One insight from the economy wide modelling is that while current policy measures can be expected to provide a boost to the SEI in general, they offer fewer advantages to NSW and some disadvantages for the state.

The majority of the expected impacts are driven by MRET, the Commonwealth Government's approach to expand the market share of renewable electricity supply. In general, MRET entails economic costs through forced utilisation of more expensive renewable generation at the expense of cheaper fossil fuel alternatives.

If effective, the current policy mix would provide incremental progress towards sustainability. Greenhouse gas emissions would contract and the share of electricity produced using renewable sources would increase modestly. Other states, however, are expected to expand their production of renewable electricity by more than NSW. Looking at the economic cost of the approach, NSW is expected to experience a deeper reduction in output (a 0.05 percent reduction in GSP in a typical year) compared to Australia at large (a typical year reduction in GDP of 0.02 percent). Overall, NSW is expected to experience a significant part of the costs and obtain fewer benefits than other states and Australia at large if the current policy approach were continued.

[1] Calls for a policy approach broadly along these lines have come from many sources. Proponents include the Federal ALP, which supports increasing MRET to 5 percent by 2010: see House of Representatives Hansard of 9 December 2002, pp 9927 ff (speaker was Mr Kelvin Thompson, Shadow Environment Minister). The Business Council for Sustainable Energy advocates increasing MRET to 10 percent by 2010: see "MRET doesn't increase market share", *EcoGeneration Magazine*, Dec 2002/Jan 2003, p9.

In contrast, adoption of a concerted range of measures to assist the SEI could advance a range of outcomes likely to be desired by the Government of NSW including:

- more jobs in the NSW SEI (an increase of 1,310 jobs) and the NSW economy at large (a net increase of 4,100 jobs);
- the opportunity to boost SEI activity in NSW, raising learning opportunities and raising the competitiveness of SEI technologies in the longer term;
- rather than imposing an economic cost, the package approach would lead to an improvement in economic efficiency boosting competitiveness and output in NSW (which is forecast to rise by 0.17 percent that is equivalent to more than $500 million per annum); and
- improved environmental outcomes as indicated by a forecast reduction in greenhouse gas emissions of 2.8 Mt CO2-e per annum.

More detailed results of the modelling are set out in Table ES.2.

Table ES.2: Policy Approaches Towards More Sustainable Energy Outcomes ¾ Macroeconomic and Greenhouse Impacts (avg. annual change 2005 to 2020)

Indicator	Demand Management Measures Scenario Three	Expansion of MRET Scenario Four	Fund to Support SEI Scenario Five*	Concerted SEI policy package Overall Net Result
Gross State Product (percentage deviation)	0.17	–0.06	0.06	0.17
Gross State Product ($m)	**510**	**–162**	**170**	**518**
NSW Greenhouse Emissions in 2020 (Mt CO2-e)	–0.1	–2.3	–0.4	–2.8
Total NSW Employment (percentage deviation)	0.1	–0.02	0.04	0.12
Emp: Fossil Fuel Elec Generation (No)	–50	–180	-40	-270
Emp: Renewable Elec Generation (No)	–20	1,140	190	1,310
Emp: Rest of Economy (No)	3,470	–1,660	1,250	3,060
Total Net Employment (No)	**3,400**	**–700**	**1,400**	**4,100**

Source: MMRF-Green Modelling Results

* While Scenario Five was modelled against a base case that included the cumulative impacts of scenarios two, three and four, the broad macroeconomic impact of Scenario Five in terms of GSP and jobs would be broadly the same if Scenario Five was undertaken in the absence of the expanded DM and renewable activity in scenarios three and four. However, this is not true of the impact of Scenario Five on the particular sectors of the energy industry. For example, a 10 percent growth in the wind sector with Scenario Five modelled against Scenario Four would be off a much higher base than if Scenario Two had been used as the base case.

The table summarises the findings of the MMRF-Green simulations for the major policy change scenarios discussed above. The results are reported in terms of variation from the base case. Thus, where negative results are reported, such as in respect of undertaking an extended MRET on its own (Scenario Four), the reduction in job numbers would generally occur in the context of a growing economy. Hence, the measure would not result in a net reduction in jobs overall but in slightly lower job growth than would have otherwise occurred. This has to be balanced against the other objectives of promoting renewable energy, such as environmental and industry development objectives.

The results suggest that each of the approaches, if pursued separately, entail a mixture of strengths and weaknesses.

Demand management measures (modelled in Scenario Three) basically enhance efficiency and competitiveness, although a growing body of international evidence demonstrates that they are unlikely to eventuate without government interventions. Thus this approach drives significant gains in NSW GSP. The efficiencies are greatest in energy using activities driving their competitiveness and raising job numbers. The implied contraction in demand for energy leads to a modest reduction in energy sector jobs, but the big picture is still one of overall job growth in NSW. The environmental gains under the approach are relatively modest.

Expansion of MRET (Scenario Four) would, by itself, provide a significant boost to SEI jobs, particularly in renewable energy supply. This boost in job numbers would be offset by jobs lost in the fossil fuel sector and overshadowed by the large numbers of jobs lost because of the economic cost of the approach. The approach would also result in progress towards a more sustainable energy industry with the scope to expand ‘learning by doing’ in renewable energy and improved environmental outcomes (indicated by expected GHG emission reductions).

The fund approach (Scenario Five) shares many of the same characteristics as demand management because it is expected that the hypothetical fund would provide a catalyst for growth of similar types of activities that would otherwise not be viable at present. The difference is that additional public spending is involved. The modelling results suggest that the economic benefits of the fund can be expected to exceed its costs, resulting in a net gain in NSW GSP. The approach also reflects an advance towards environmental improvements indicated by a reduction in GHG emissions.

Clearly, the combination of approaches offers the opportunity of obtaining the favourable outcomes and offsetting the disadvantages of the variety of approaches available.

ES.7 Options for Capturing SEI Investments in NSW

NSW can arrest the potential SEI investment outflows under current State policy settings by showing leadership in SEI market development. In addition to effective voluntary instruments, a basket of regulatory and industry development options are available to achieve this objective. Regulatory options include:

- enforceable DM licensing provisions;
- establishing an SEI investment fund;
- strengthening training and certification;
- lifting home and building star rating requirements; and
- community stewardship programs to facilitate local buy-in to generation projects.

ES.8 Overarching Themes

There are emerging opportunities from the development of the global, national and regional markets for the sustainable energy industry (SEI).

The SEI in Australia faces a mixture of market and regulatory failures that pose significant barriers to entry. Reflecting some existing policy support to address these issues, and a desire to boost practical experience in applying these technologies, renewable energy supply is growing rapidly from a small base. While studies consistently reveal significant commercial gains from investment in DM, many opportunities seem to be under-utilised at present.

Economy wide assessment of the current policy mix in the energy sector in Australia suggests that incremental progress towards environmental sustainability, measured in terms of lower greenhouse gas emissions, will be achieved at a cost to economic wellbeing in terms of reduced output and consumption potential. The outlook for NSW is less encouraging, as it appears that that state will bear a disproportionately high share of the costs and enjoy a disproportionately low gain in SEI activity and jobs.

The SEI could contribute to job growth in NSW in the SEI and over the economy at large while also enhancing environmental outcomes, with adoption of a package of measures. Key elements of such a package would include measures to directly stimulate: renewable energy development, increased energy efficiency through DM and provide ‘catalytic’ funding for adoption of other SEI technologies.

In a competitive national energy market, States that establish a strong and dynamic SEI sector will build a significant first mover advantage. The modelling indicates that NSW can generate strong economic and employment gains and SEI industry development if it adopts a suitable package of measures. These gains will shift to other states if the NSW Government declines to act.

It is particularly timely for NSW to consider these issues given that, for the first time in nearly two decades, significant new investment is required in NSW to meet forecast growth in demand for energy services.[2] Given that investment in new generation capacity will have long lived impacts, decisions taken now will carry implications well into the future.

2 NSW Ministry of Energy and Utilities, *Statement of System Opportunities*, 2002.

1 Introduction

This chapter sets out the aims of the study and provides context for the analysis that follows.

1.1 The Study

The Allen Consulting Group was commissioned by the Sustainable Energy Development Authority (SEDA) to conduct a study on the impact on jobs in NSW of measures to expand the Sustainable Energy Industry (SEI). A copy of the study brief is at Appendix L. In undertaking the study, The Allen Consulting Group was assisted by the Centre of Policy Studies at Monash University and Gutteridge, Haskins & Davey (GHD).

The brief sought a report covering a range of issues and analyses related to expanding the SEI in NSW. In broad terms, these issues (and their relevant chapters in this report) included:

- an overview of the SEI industry, the drivers of technological change and the competitiveness of sustainable energy technologies (Chapters One to Six);
- a detailed discussion of seven sustainable energy technologies with future potential for expansion in NSW (Chapter Seven);
- economy-wide modelling of a range of scenarios based on an expansion of the SEI in NSW, focussing particularly on the impact on jobs, economic activity and greenhouse gas emissions abatement in NSW (Chapter Eight and Appendices A to J); and
- the identification of strategies to encourage the NSW SEI (Chapter Nine).

The study also includes a Wind Manufacturing Case Study, which is published as a separate, stand-alone report.

1.2 The SEI

This study takes a broad approach to the composition of the Sustainable Energy Industry (SEI). The SEI is viewed as being comprised of energy related products, processes and services that:

- improve environmental integrity, including through the reduction of greenhouse gas emissions; and
- enhance commercial and economic outcomes.

There is a very wide range of activities that are often considered as being SEI technologies. Technologies frequently listed include[3]:

- solar thermal and photovoltaic;
- wind energy;
- biomass;
- waste-to-energy technologies;
- cogeneration;
- coal seam methane;
- small scale hydroelectricity generation;
- energy efficient building design; and
- insulation products.

SEI technologies may also involve approaches that change community and industry values, norms and behaviours that enhance energy sustainability. Examples include:

- raising awareness about the implications of energy choices; and
- changing consumer preferences in favour of the adoption of more sustainable approaches.

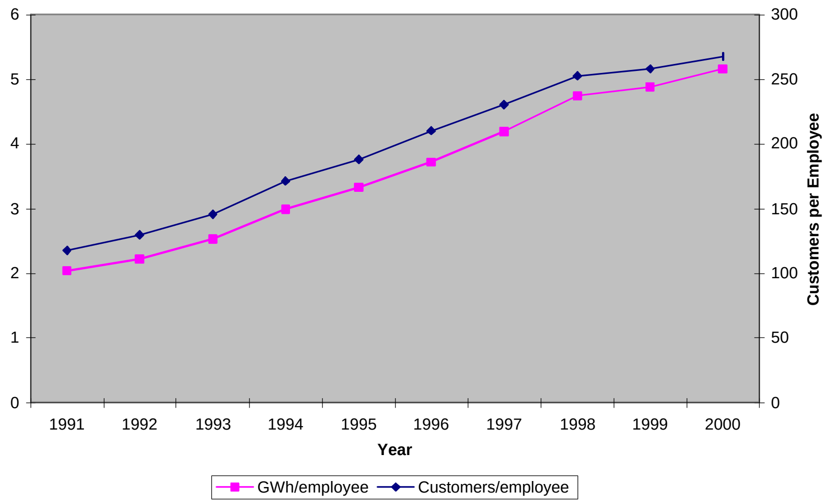
1.3 Energy Industry Employment

The situation for jobs in the current energy market context has been bleak. Between 1997 and 2001, 4,537 jobs were shed from the coal sector in NSW,[4] representing a 32 percent decline. Deregulation and technological change have improved productivity but with it has come a loss of jobs in the industry — see Figures 1.1 and 1.2. Consultations with industry sources indicate that on an annual basis, productivity gains in the electricity sector continue at around 2 percent per annum.

3 See for example technologies listed in Sustainable Energy Development Authority of NSW, *2001-02 Annual Report*, pg 5.

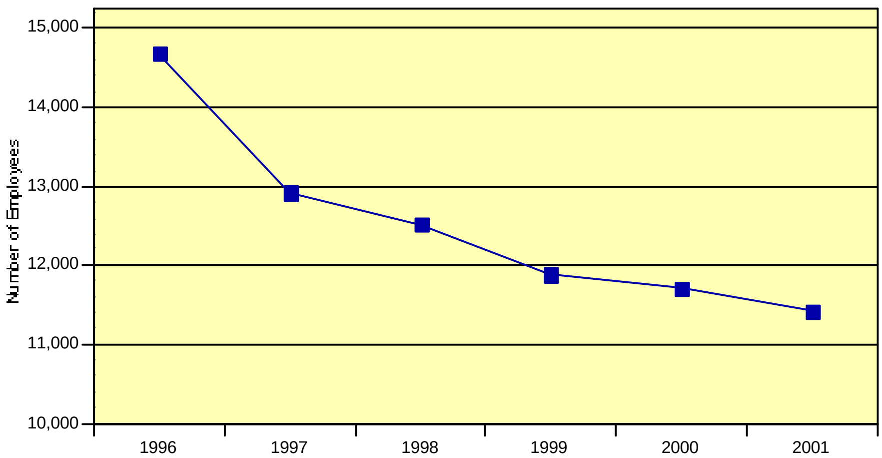
4 For employment and output statistics, see www.minerals.nsw.gov.au/geosurvey/coal/table.htm

Figure 1.1: Labour Productivity



Source: Electricity Supply Association of Australia Limited, *Electricity Australia*, 2002

Figure 1.2: Employment in Electricity Industry — NSW and ACT



Source: Electricity Supply Association of Australia Limited, *Electricity Australia*, 2002

As a productivity measure, saleable output per employee has grown from $6,920 for the year ending 1996-97 to $11,570 for the year ended 2000-01. Competition policy reforms have succeeded in lifting productivity in the energy sector, however, as a result, employment in the sector has fallen. Between 1999-00 and 2000-01 there was a slight rise of 266 jobs, but this is due to cyclical growth as opposed to structural change.

Expanded SEI employment could potentially offset the decline in conventional energy job losses. For example, energy efficiency measures would create jobs in the demand management service sector and in the economy more broadly, as industry and households spend energy savings on other job-creating activities. As highlighted as a finding from other parts of this study strong leadership will be required to ensure that job opportunities in the NSW SEI are realised.

2 World Energy Supply and Demand

This chapter looks at recent and forecast world energy supply and electricity generation over the period 1971 to 2030, highlighting the prospects for growth in renewable energy technologies in particular. A key message from energy forecasts is the limited outlook for renewables in the absence of strong government action. Such action is taking place overseas with many countries adopting measures to encourage renewable energy and reduce energy consumption. Forecasts in relation to renewable energy are therefore likely to be revised up as these policies take root. This is likely to create significant SEI export and investment opportunities for jurisdictions that establish a technological lead in sustainable energy technologies. This is so for Australia and NSW given its close proximity to the rapidly growing and developing Asia Pacific region.

2.1 Introduction

In the absence of new policies to curb energy use and greenhouse gas emissions, the International Energy Agency (IEA) estimates that world energy demand will grow by 66 percent and CO2 emissions by 69 percent between 1995 and 2020. This Reference Scenario describes a world similar to that of today but with a much larger role played by developing countries. Under the Reference Scenario, fossil fuels are expected to provide 95 percent of additional global energy demand to 2020. The reference scenario assumes the continuation of policies to reduce energy demand and greenhouse emissions in place in mid 2002. It provides a benchmark against which to evaluate the challenge of devising policies to meet energy and environmental policy objectives.

The IEA has also assessed the impact on energy demand and emissions of an Alternative Policy Scenario. This Scenario assumes the introduction of a range of policies by OECD countries to address concerns about unsustainable energy market outcomes including the need to reduce energy demand and greenhouse gas emissions such as:

- improved vehicle fuel efficiency;
- increased use of alternative fuels and vehicles;
- reductions in travel demand growth (eg, through reforms to urban road pricing);
- increased efficiency of household appliances; and
- increased thermal efficiency of buildings.

The Alternative Policy Scenario recognises that efforts to reduce greenhouse gas emissions in order to meet Kyoto Protocol targets — as well as other concerns such as energy security — are likely to see OECD countries undertake a range of additional measures. Long-term plans are likely to see further emphasis on renewables and on energy efficiency.

The IEA projects that, under the Alternative Policy Scenario, total primary energy demand in the OECD will be 69 Mtoe lower in 2010 than under the Reference Scenario.

Savings will be 529 Mtoe, or 9 percent, by 2030. However, projections of world demand under the Reference Scenario show that this effect will be diluted by the OECD's projected falling share in world primary energy demand, from 58 percent in 2000 to 54 percent in 2010 and 47 percent in 2030. This arises above all from rapidly rising demand in developing countries, particularly Asia.

It is important to note that energy markets could evolve in ways that are much different from either the Reference Scenario or the OECD Alternative Policy Scenario. Thus, projections of world energy supply and demand over the coming decades are subject to considerable uncertainties. The most important of these are:

- macroeconomic conditions in global, regional and individual economies;
- resource availability, supply costs and prices, particularly the cost of extraction and transportation;
- energy technology;
- energy and environmental policies, particularly in relation to environmental protection (climate change) and energy security; and
- investment in energy supply infrastructure.[5]

While the future remains uncertain, the thrust of outcomes predicted under the Alternative Policy Scenario is becoming more likely, given growing international momentum behind the Kyoto Protocol. The Protocol's entry into force would mark an important shift towards internalisation at a global level of environmental externalities associated with energy production and use. This would mark a major shift in energy regulation and will impact significantly on what constitutes 'business as usual' in future.

Analysis of the Alternative Policy Scenario raises important implications for New South Wales and Australia when seeking to maintain and grow competitiveness. The findings from the Scenario poses a policy challenge: that of keeping pace with — and managing the impact of — international moves to support sustainable energy generation and use. It also highlights the potential opportunity to participate in and benefit from the emerging sustainable energy technology markets.

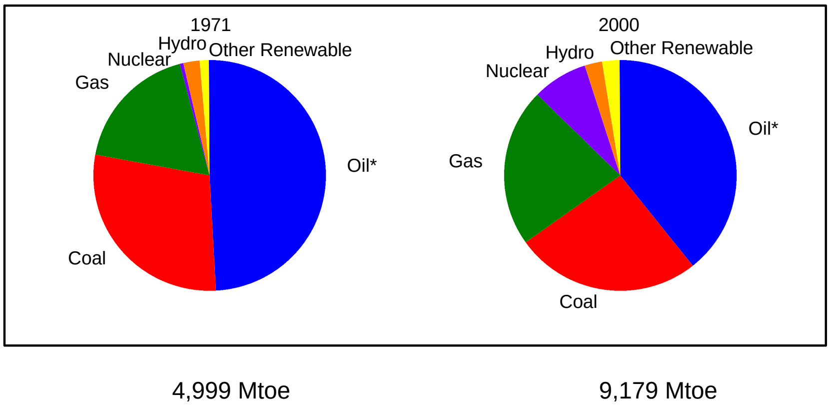
The detailed outlook for world energy demand under the Alternative Policy Scenario is outlined in the relevant section below.

5 International Energy Agency, *World Energy Outlook 2002*, p.54

2.2 World Energy Supply

Figure 2.1 shows the contribution to world total primary energy supply (TPES) of different fuels between 1971 and 2000 in terms of million tonnes oil equivalent (Mtoe). The figure shows that most of the increase in energy supply over the period has come from an expansion in the use of gas and nuclear fuels. Hydropower has also increased but still represents a small contribution to world energy supply. The contribution of other renewables is also small and is mainly accounted for by combustible renewables, which is largely wood burning in developing countries. A key highlight in terms of renewable energy is that, apart from hydro, the share of renewable energy just keeps pace with overall growth.

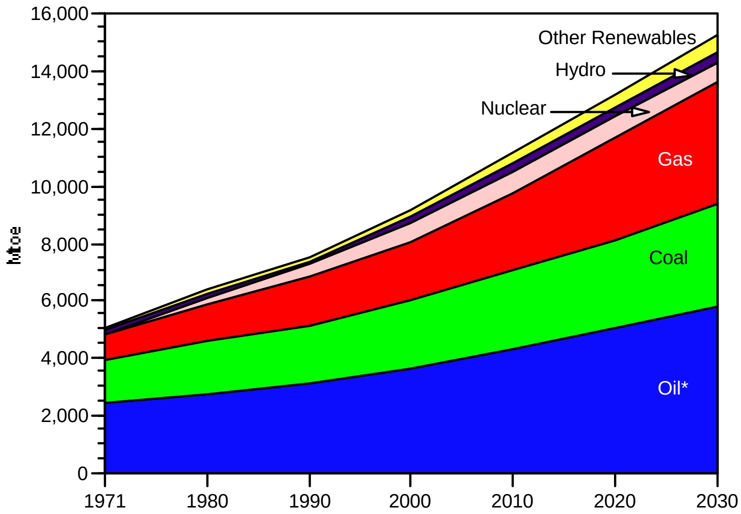
Figure 2.1: Shares of World TPES by Fuel: 1971 and 2000



Source: International Energy Agency, *World Energy Outlook 2002*, p.410
* Includes international marine bunkers.

Figure 2.2 shows the growth in world TPES by fuel over the period 1971 to 2000 as well as projections to 2030 under the Reference Scenario.

Figure 2.2: Growth in World TPES by Fuel: 1971 to 2020

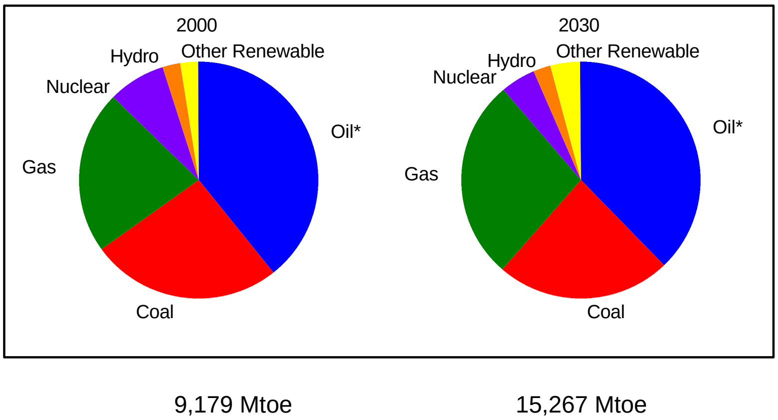


Source: International Energy Agency, *World Energy Outlook 2002*, p.410.
* Includes international marine bunkers.

The figure shows that gas will grow most strongly as a fuel over the next three decades while nuclear power will lose share and hydro will increase its share. The share of renewables appears to grow relatively strongly but, as is shown more clearly in Figure 2.3, does not result in an increase in its overall share of world TPES in 2030, which remains small.

These results are confirmed by the snapshot of fuel shares in 2000 and 2030 shown in Figure 2.3.

Figure 2.3: Shares of World TPES by Fuel: 2000 and 2030



Source: International Energy Agency, *World Energy Outlook 2002*, p.410.
* Includes international marine bunkers.

The increase in the share of gas is readily apparent in the figure, as is the decline in the share of nuclear power and in increase in hydro. Renewable energy grows in absolute terms but not fast enough to actually increase it share of TPES in 2030.

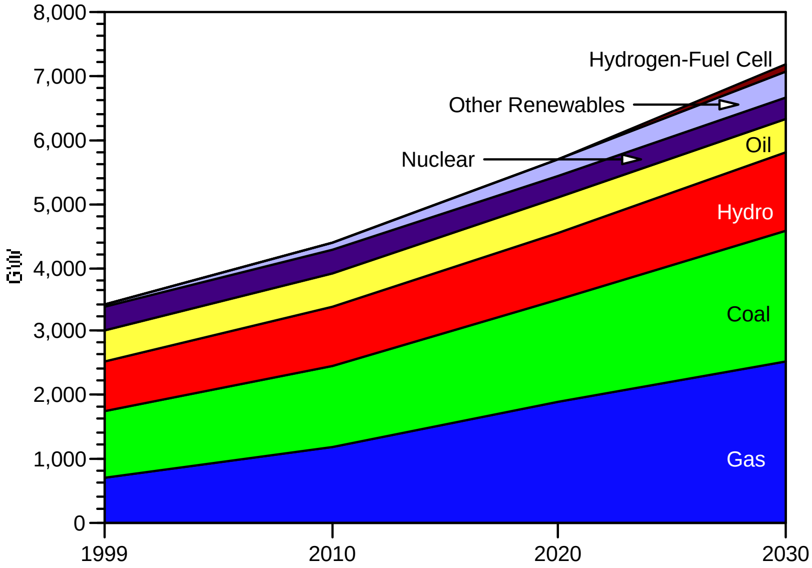
2.3 World Electricity Generation

2.3.1 Reference Scenario

Figures 2.4 and 2.5 show the growth in world electricity generation by fuel over the three decades to 2030 under the Reference Scenario. The figures show that:

- world electricity generation from gas is expected to increase significantly;
- the growth of coal is expected to be in line with the increase in generation;
- the growth of hydro, oil and nuclear will be below average; and
- the growth of other renewables and hydrogen fuel cells will be above average.

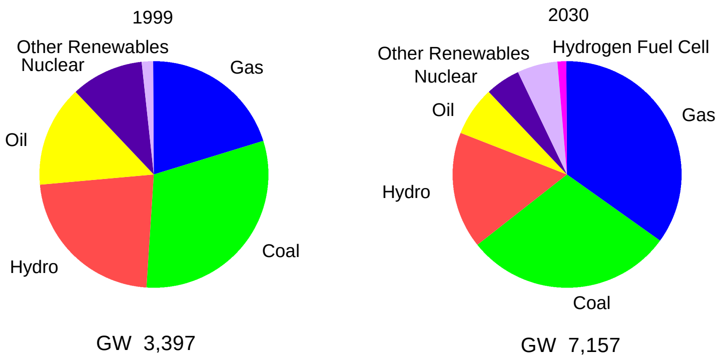
Figure 2.4: Capacity of World Electricity Generation by Fuel: 1999 to 2030 (GW)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

The outcomes in terms of the future share of different fuels of the different growth rates shown in the figure above are shown in Figure 2.5. The figure shows more clearly the increase in the share of gas at the expense of hydro, oil and nuclear. The increase in the share of non-hydro renewables and fuel cells is also apparent but they would still only contribute a small proportion of generation capacity in 2030.

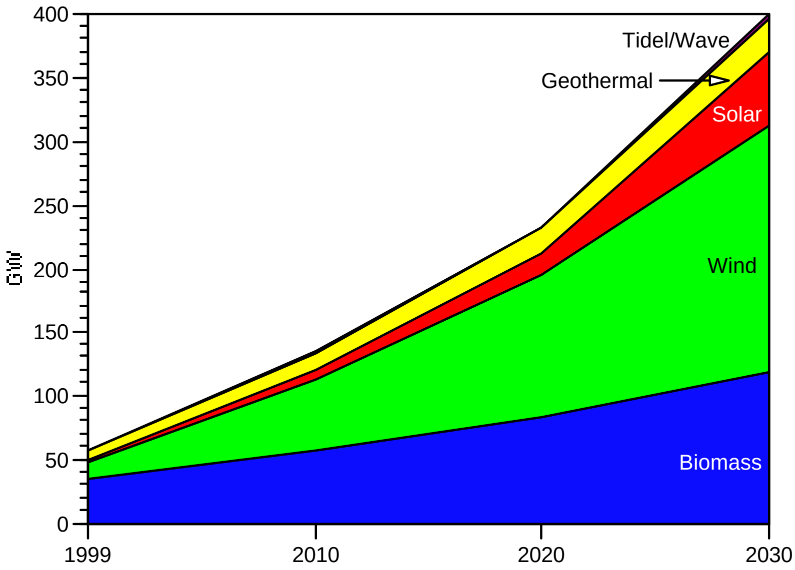
Figure 2.5: Shares of World Electricity Generation Capacity by Fuel: 1999 and 2030 (GW)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

Figures 2.6 and 2.7 show the Other Renewables Category from Figures 2.4 and 2.5 in more detail. A key highlight is the strong increase in solar and wind generating capacity, particularly after 2020, while geothermal, biomass and tidal/wave increase at below average rates, losing share over time.

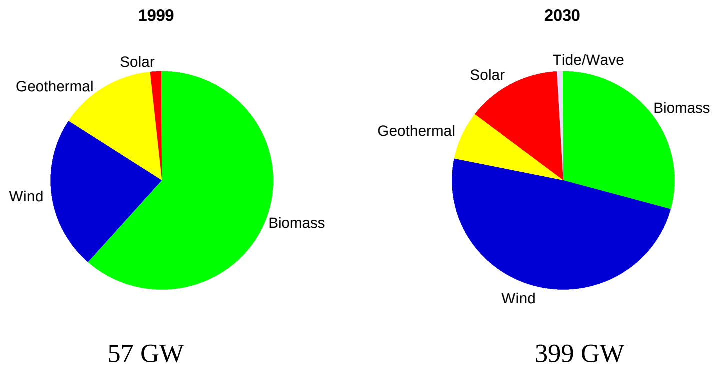
Figure 2.6: Capacity of World Renewable Electricity Generation by Fuel: 1999 to 2030 (GW)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

The outcomes of the trends shown above are clearly shown in Figure 2.7 where the share of solar and particularly wind are seen to increase at the expense of biomass and geothermal. Indeed, the figure suggests that nearly half of non-hydro renewable electricity generating capacity in 2030 will come from wind. However, the proportion of non-hydro renewable capacity in 2030 is still relatively small, increasing only to 6 percent compared to 2 percent in 1999.

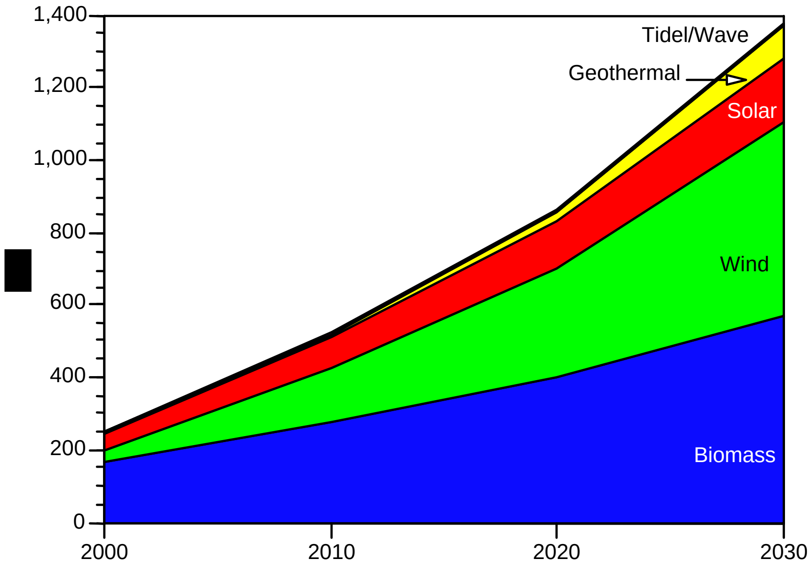
Figure 2.7: Shares of World Renewable Electricity Generation Capacity by Fuel: 1999 and 2030 (GW)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

The figures above are based on generation capacity. On the other hand, Figure 2.8 shows the growth in electricity generation in terms of TWh from renewable sources. In terms of generation, the increase in biomass and geothermal are larger and wind smaller compared with the picture in relation to renewable capacity.

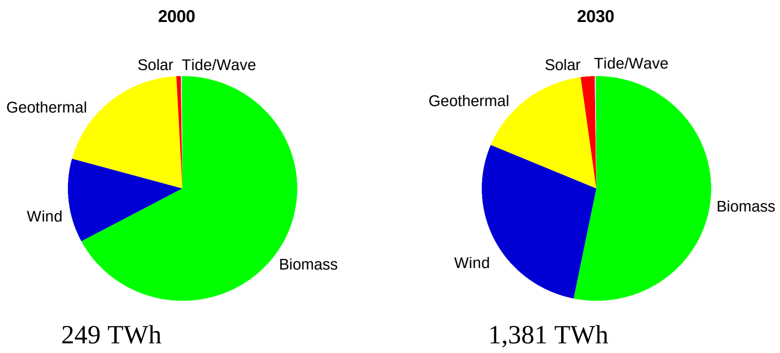
Figure 2.8: Growth in World Renewable Electricity Generation by Fuel: 2000 to 2030 (TWh)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

This is shown more clearly in Figure 2.9. While wind represented nearly half of renewable capacity in 2030 and biomass around 30 percent, in terms of generation, biomass is projected to generate more than half of world non-hydro renewable electricity in 2030 and wind around 30 percent.

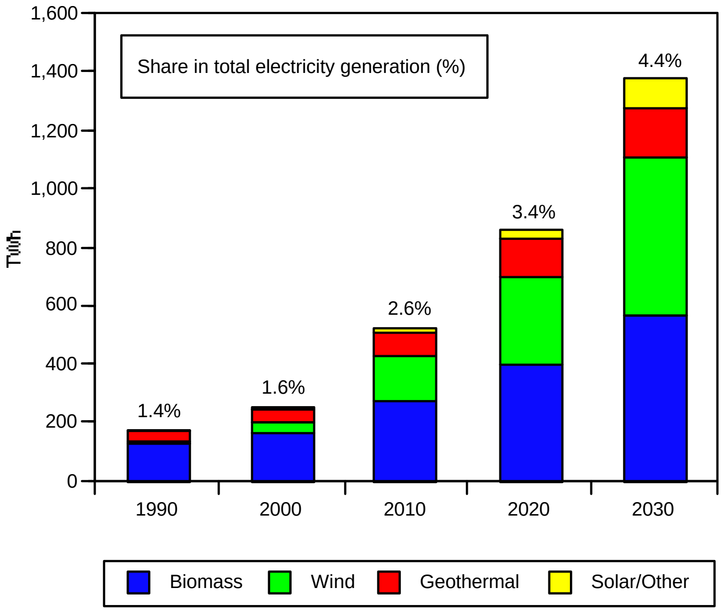
Figure 2.9: Shares of World Renewable Electricity Generation by Fuel: 2000 and 2030 (TWh)



Source: International Energy Agency, *World Energy Outlook 2002*, p.411.

Figure 2.10 shows the breakdown of world renewable electricity generation by fuel between 1990 and 2030 and the total share of renewable energy in total world electricity generation.

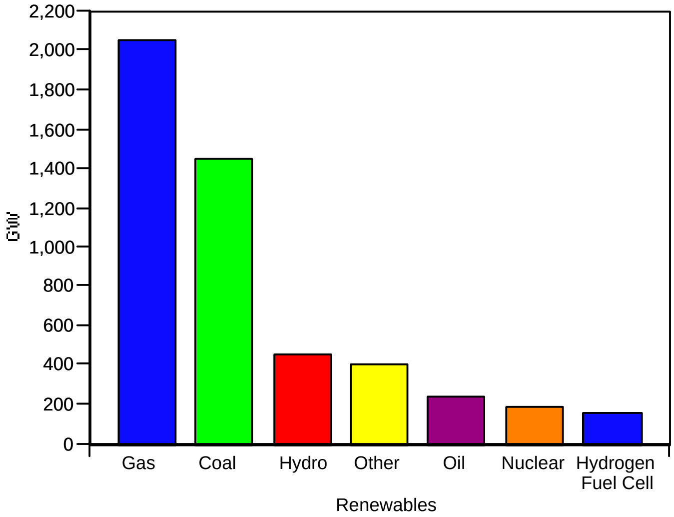
Figure 2.10: World Electricity Generation by Fuel (TWh)



Source: International Energy Agency, *World Energy Outlook 2002*, p.131.

Finally, Figure 2.11 shows the projected capacity additions to world electricity generation capacity by fuel over the period 2000 to 2030.

Figure 2.11: World Electricity Generation Capacity Additions by Fuel: 2000 to 2030 (GW)



Source: International Energy Agency, *World Energy Outlook 2002*, p.131.

2.3.2 Alternative Policy Scenario

Under the Alternative Policy Scenario, electricity generation increases only 0.9 percent per year to 2030, compared with 1.3 percent under the Reference Scenario. A key development is that the fossil fuel input to electricity generation is around 24 percent less in 2030 compared with the Reference Scenario. Other highlights include:

- coal-fired generation in the OECD is reduced 30 percent compared with the Reference Scenario;
- gas continues to grow in usage, although much more slowly than under the Reference Scenario; and
- wind, biomass and to some extent other renewables grow strongly under the Alternative Policy Scenario. The share of all renewables in electricity generation, including hydropower, rises from 14.7 percent in 2000, to 17.6 percent in 2010 and to 25.4 percent in 2030.

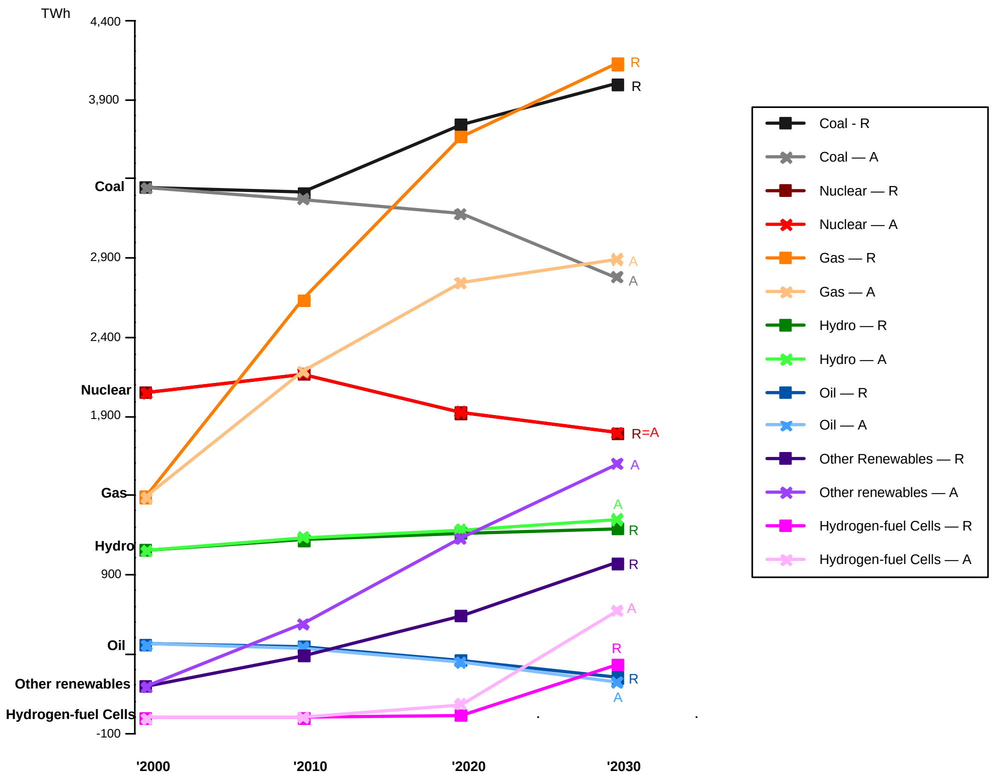
The Alternative Policy Scenario, based on additional policies and measures under consideration in OECD countries, leads to a reduction in CO_2 emissions below the Reference Scenario for 2030 amounting to 19 percent in the European Union, 15 percent in Australia, Japan and New Zealand combined and 14 percent in the United States and Canada. OECD total primary energy demand in 2010 would be 69 Mtoe lower than the reference case and by 2030, would be 529 Mtoe less — equivalent to a reduction of 9 percent on the Reference Scenario for the OECD.

In each region, savings in the power sector make the largest contribution to these savings, due mainly to policies that promote renewables and reduce electricity demand. The European Union's larger percentage reductions are due in part to their more aggressive renewables targets.

In 2010, natural gas accounts for the largest share of energy and CO_2 savings. CO_2 emissions reductions attributable to lower coal consumption increase rapidly after 2010: by 2030, reduced coal generation represents half of the CO_2 savings in the Alternative Policy Scenario.

Figure 2.12 shows the changes to electricity generation projections within the OECD under the Alternative Policy Scenario as a result of policies promoting the increased use of renewables, co-generation and improved efficiency. The reduction in coal-fired generation is clearly apparent, as is the significant reduction in the growth of gas-generated electricity. Both these reductions are offset by significant increases in non-hydro renewables. Of particular interest is the sharp increase in electricity sourced from hydrogen fuel cells after 2020.

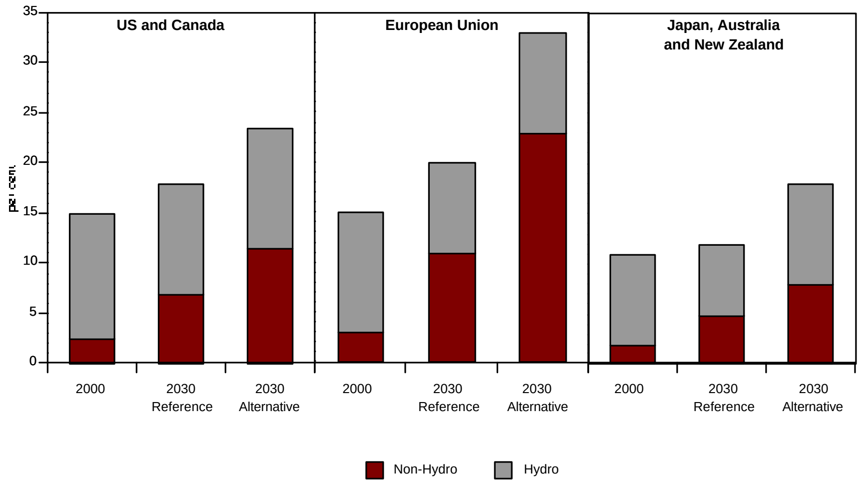
Figure 2.12: OECD Electricity Generation Mix in the Reference and Alternative Policy Scenarios



Source: International Energy Agency, *World Energy Outlook 2002*, p.362.

Figure 2.13 shows the impact on the share of renewables in electricity generation under the Reference and Alternative Policy Scenarios. Increases are most marked in the EU, where the share of renewables in 2030 increases to around one-third under the Alternative Policy Scenario compared to around one-fifth under the Reference Scenario. Increases in the share of renewables are smaller, although still significant, under the Alternative Policy Scenario in North America and Japan, Australia and New Zealand.

Figure 2.13: Share of Renewables in Electricity Generation in the Reference and Alternative Policy Scenarios



Source: International Energy Agency, *World Energy Outlook 2002*.

Under the Alternative Policy Scenario, non-hydro renewables are projected to grow by some 4 percent per annum between 2000 and 2030, compared to 2.7 percent under the Reference Scenario.

2.4 Government Support for Renewable Energy: International Experience

The relatively limited future for renewables in terms of their contribution to world electricity generation under the Reference Scenario is highlighted in Figures 2.5 to 2.9. The reason for this is the continued relatively poor competitiveness of renewable technologies compared to fossil fuels, which is forecast to still be the case in 2020. This issue is discussed further in Chapter Four and highlights the fact that without continued support from governments to promote renewables, their future as a source of both energy and electricity will be limited. This support will be necessary while the negative externalities associated with fossil fuels, including greenhouse gas emissions and other problems such as NOx and SOx pollution, are not factored into the price of energy and electricity produced by these fuels, and while renewables remain a relatively high-cost abatement option.

Table 2.1 details the policies in place in IEA countries to promote renewable energy. Some policy types such as competitive bidding procedures and "green pricing" are rapidly becoming more common. Increased information availability and dissemination has resulted in countries learning from each other’s renewable energy policy successes. This can be illustrated by France and Ireland, both of which initiated competitive bidding procedures for renewable electricity projects of a type similar to that found in the UK’s Non–Fossil Fuel Obligation (NFFO) after the NFFO had been in operation for a number of years. Moreover, developers of the French and Irish policy learnt from early NFFO orders and instigated policies that guarantee prices for up to fifteen years (rather than six or eight, as in early rounds of the NFFO). When the period over which there is a guaranteed electricity market increases, developers can bid lower electricity prices as their amortisation period is longer.

Although green pricing schemes have been available in parts of the US for a number of years, it was the Netherlands that first introduced the concept in Europe in 1996. By early 1998, distributors in Germany, Sweden, Denmark, Switzerland and the UK had followed suit. One area of renewable energy policy that is surprisingly rare is the explicit evaluation of the successes of renewable energy policies. Switzerland and Spain carry out regular evaluations of progress towards their target and Ireland carried out a thorough evaluation of its renewable energy policy after the first round of its Alternative Energy Requirement. However, systematic evaluation of policies is the exception rather than the rule. The numbered code used in Table 2.1 to identify particular polices is set out in Box 2.1.

Table 2.1: Renewable Energy Policy in IEA Countries (numbering code is on the following page)

Country	**Electricity Supply Industry**		**Green Pricing***	**Economic or Fiscal Incentives**	**Regulatory Measures or Standards**	**Information and Education**	**Other Targets or Quotas**	**Voluntary Actions**
	Output/ Capacity Targets/ Quotas	*Favourable/ Guarantee markets*						
Australia	Yes		Yes	Yes 2, 3	Yes 3	Yes 4		Yes
Austria		Yes	Yes	Yes 1, 2		Yes 4		Yes
Belgium				Yes 1, 2, 3, 5	Yes 1, 4	Yes 1, 4	Yes 7	
Canada				Yes 1, 3		Yes 1, 2		Yes
Denmark	Yes, cap	Yes	Yes	Yes 1, 5	Yes 1, 4, no landfill	Yes	Yes 1, 2	
Finland				Yes 1, 3	Yes 1, 2, 4	Yes 1, 2, 4	Yes 5	Yes
France	Yes, cap	Yes, wind only		Yes 1, 3, 4 (low VAT)	Yes 4	Yes	Yes 3, 6 (wood)	
Germany			Yes	Yes 1, 2, 3, 4	Yes 1, 3	Yes 1, 3, 4		Yes
Greece	Yes	Yes		Yes 1, 3		Yes 1, 4	Yes 1, 5	
Hungary				Yes 1, 2				
Ireland	Yes, cap	Yes		Yes 1, 3		Yes 1, 3, 4		
Italy	Yes, cap	Yes		Yes 3	Yes 3			
Japan	Yes, cap	Yes		Yes 1, 2, 3	Yes 1	Yes	Yes 1, 6	Yes
Luxembourg		Yes		Yes 1, 3		Yes		
Netherlands	Yes, output	Yes (<8MW)	Yes	Yes 3, 5	Yes	Yes 1, 3, 4	Yes 1, 7	Yes
New Zealand				Yes 3	Yes 4	Yes 1, 5		
Norway				Yes 1 (3 planned)		Yes 4		Yes
Portugal	Yes, cap	Yes		Yes 1, 2, 3	Yes 3	Yes 1, 4		
Spain	Yes, both	Yes		Yes 1			Yes	
Sweden		Yes, g/f	Yes	Yes 1, 3, 5	Yes			
Switzerland	Yes	Yes	Yes	Yes 1		Yes	Yes 5, 7	Yes
Turkey	Yes, cap			Yes	Yes	Yes	Yes, regional	
UK	Yes	Yes	Yes	Yes 1	Yes	Yes		Yes
USA	Yes, PURPA		Yes	Yes 1, 5	Yes	Yes	Yes	Yes
EU				Yes 1, (3), 4 (R&D)	Yes	Yes	Yes 7	

Source: International Energy Agency, *Renewable Energy Policy in IEA Countries, Volume II: Country Reports*, Energy and Environment, Policy Analysis Series.

* No country has nationwide green pricing, it is only available on a state/regional basis, although all States in a country may have green pricing (eg, Australia).

Box 2.1: Numbering Code for Table 2.1

Economic and Fiscal Incentives

1 Grants and subsidies involving direct transfers

2 Credit instruments (interest rate loans, soft loans, loan guarantees)

3 Tax exemptions (tax reliefs, credits, deferrals)

4 Others

5 Output credit for renewable electricity (on top of normal electricity buyback rate).

Regulatory Measures and Standards:

1 Planning/siting legislation

2 Survey requirements or mapping.

3 Building codes

4 Others (generally waste-related)

Information and Education

1 Publications, advertising campaigns

2 Courses for industry

3 Education programmes in schools and workplaces

4 Renewable energy advice centres

5 Others

Other targets

1 Solar heat

2 Passive solar

3 Bio-fuel

4 Heat pumps

5 Heat production

6 Other

7 Total

Source: International Energy Agency, *Renewable Energy Policy in IEA Countries, Volume II: Country Reports*, Energy and Environment, Policy Analysis Series.

The general conclusion from the table is that all IEA countries currently have in place measures to encourage the sustainable use of energy. However it is important to note that different types of policies have varying levels of effectiveness in terms of growing sustainable energy. Growth in the renewables sector has been strongest in those countries (such as Germany and Denmark) where policies have provided effective and targeted support for technologies such as wind. As indicated through the results of the IEA's Alternative Policy Scenario which factors in measures additional to those included in the table above, further policy intervention is required in energy markets if the share of renewable energy is to increase.

2.5 Conclusion

The outlook for sustainable energy is bleak without public policy intervention by Government to adjust energy market outcomes. The IEA's Reference Scenario suggests continued global reliance upon fossil fuels without policy intervention.

Governments overseas, however, are acting unilaterally and multilaterally, placing increased emphasis upon combating market failures in energy markets and are increasingly supportive of more sustainable energy outcomes, including through policies intended to expand the role of renewable electricity supply. Given this support and expected strong growth in energy demand, especially in developing countries in the Asia Pacific region significant opportunities for exporting sustainable energy technologies will emerge.

Tapping into these opportunities from Australia and New South Wales raises challenges for Government policy. Further Chapters of this report show how Government support is needed to assist the growth of the sustainable energy sector and help it realise benefits from reduced environmental impacts, greater energy market supply diversity and security of supply, export opportunities and job growth.

3 Australian Energy Supply and Demand

This chapter sets out the details of past and forecast energy demand and supply and electricity generation in Australia and NSW in particular. Projections for Australia are not dissimilar to those for the world as a whole in terms of the relatively limited share expected for renewable energy in total energy or electricity supply without Government support and policy intervention. Growth rates for renewables are high but they are off such a low base that non-hydro renewables are only projected to supply 3.6 percent of Australian electricity generation in 2020.

A key message is that the growth in renewable energy that is expected is linked to government policies to intervene in the energy market that are specifically intended to boost the situation of renewable energy.

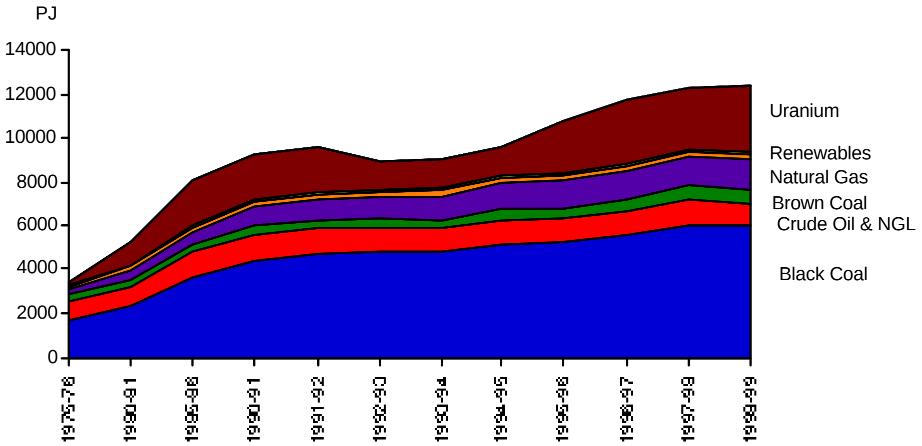
Against this background, opportunities for export and investment in the SEI industry are likely to be shaped by policy initiatives taken by jurisdictions anxious to develop a firm base in sustainable energy. Reflecting factors that impact upon competitiveness that are discussed in further chapters those jurisdictions that act sooner will be in a stronger competitive position to take advantage of their domestic and global opportunities. Recognising the potential of the SEI, other countries and Australian States are outpacing NSW in a number of areas. There is a limited window of opportunity for NSW to deal itself into the game. Without a strongly supportive and proactive policy response, NSW will find itself left behind.

3.1 Australian Energy Production — Historical Trends

Official data about Australian energy production are available from the Australian Bureau of Agricultural and Resource Economics (ABARE). Figure 3.1 shows Australia's energy production by fuel between 1975 and 1999. The shape of the figure is somewhat distorted between 1975 and 1991 because data is only available at five-yearly intervals. However, over the period, a number of trends are apparent, including:

- the steady growth of black coal;
- the early growth of oil up to the late 1980s and its subsequent levelling out until it begins to decline slightly in the late 1990s;
- the strong growth in the production of natural gas;
- the small but consistent level of production of renewables, which over this period is made up mainly of Tasmanian and Snowy hydro; and
- the long term growth of uranium, although it did decline temporarily in the early 1990s.

Figure 3.1: Australian Energy Production by Fuel: 1975 to 1999

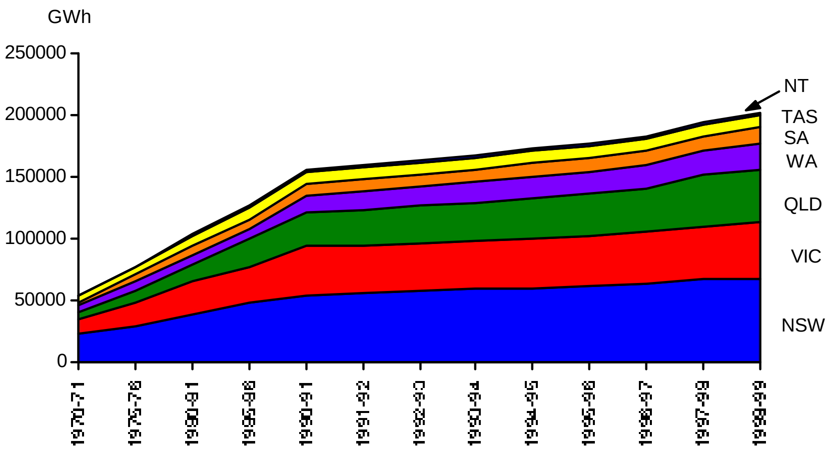


Source: Australian Bureau of Agricultural and Resource Economics, *Overview Dataset 1960-1999*, unpublished.

3.2 Australian Electricity Consumption — Historical Trend

Figure 3.2 shows Australian electricity consumption by state over the period 1970 to 1999. Again, the shape of the figure is distorted because of the use of five-yearly data up to 1990. However, the data shows a gradual increase in electricity consumption over time consistent with a mature industrial economy.

Figure 3.2: Consumption of Electricity by State: 1970 to 1999



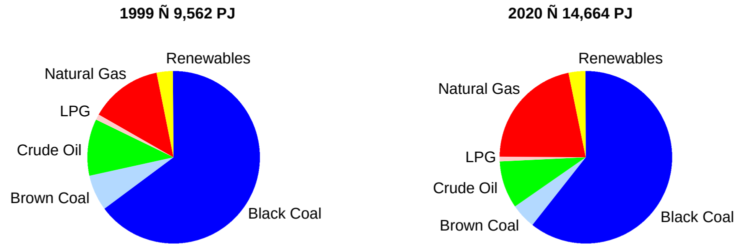
Source: Australian Bureau of Agricultural and Resource Economics, *Overview Dataset 1960-1999*, unpublished.

3.3 Australian Energy Supply — Outlook to 2020

Figure 3.3 shows the projected energy production by fuel in Australia in 1999 and 2020. It is projected that between 1999 and 2020 the share of:

- black coal will fall from 64.7 to 60.6 percent;
- brown coal will fall from 6.7 to 4.8 percent;
- crude oil will fall from 11 to 8.9 percent;
- LPG will fall slightly from 1.1 to 0.9 percent;
- natural gas will increase significantly from 13.6 to 21.7 percent; and
- renewables will increase slightly from 3 to 3.2 percent.

Figure 3.3: Australian Energy Production by Fuel: 1999 and 2020

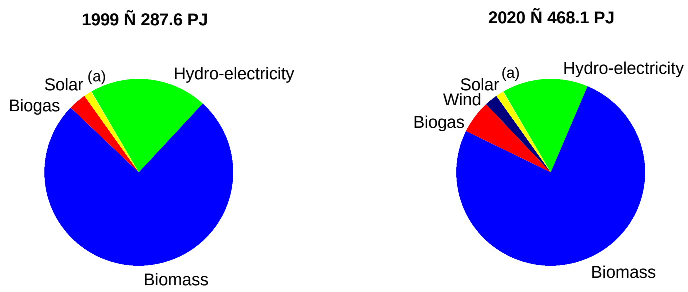


Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.57.
Note: LPG is naturally occurring LPG. Crude oil includes condensate.

Figure 3.4 breaks out the renewable sector in the figure above and shows that, over the period:

- hydroelectricity will fall from 0.6 to 0.5 percent;
- biomass will increase slightly from 2.3 to 2.4 percent;
- biogas will increase from 0.1 to 0.2 percent;
- wind energy increases from less than 0.05 (0.1 PJ) to 0.1 percent (11.1 PJ); and
- solar energy, the figures for which are rounded to 0.0 in both years, will increase from 3.8 to 6.1 PJ.

Figure 3.4: Australian Renewable Energy Production by Fuel: 1999 and 2020



Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.57.
Note: (a) means share is less than 0.05 percent and hence appears as a zero in the ABARE data which rounds to only one decimal place.

Average annual growth rates for the data shown in Figures 3.3 and 3.4 are shown in Table 3.1.

Table 3.1: Australian Energy Production ¾ Average Annual Growth: 1999 to 2020

Fuel	Ave Annual Growth
Black Coal	1.7
Brown Coal	0.4
Crude Oil	1.0
LPG	0.9
Natural Gas	4.4
Hydroelectricity	0.8
Biomass	2.4
Biogas	5.1
Wind Energy	25.2
Solar Energy	2.3
Average	4.4

Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20, ABARE Research Report 01.11*, October 2001, p.57.

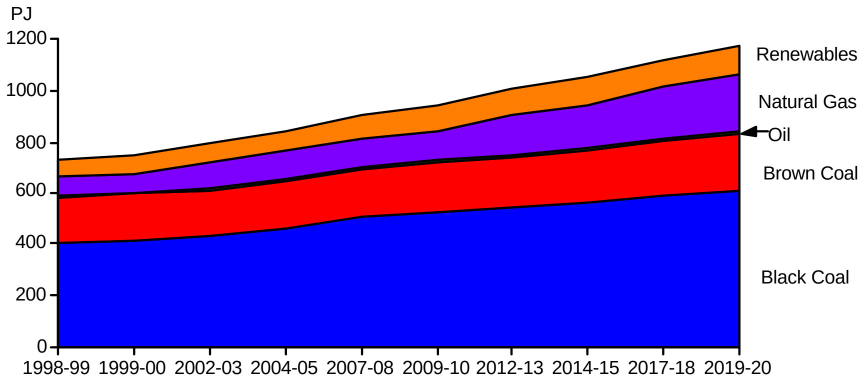
The table shows that growth in fossil fuels except natural gas will be below the average of 4.4 percent while renewables (except hydro) will be higher. Wind grows most strongly, reflecting its low base. While biomass growth is only a little above the average, as Figure 3.4 indicates, this is off a relatively high base.

3.4 Australian Electricity Generation — Outlook to 2020

Figure 3.5 shows projections to 2020 for Australian electricity generation by fuel. The data shows a:

- continued steady increase in the use of black coal;
- stagnation in the share of brown coal;
- continued minor contribution by oil;
- strong increase in the use of natural gas; and
- growing share for renewables.

Figure 3.5: Australian Electricity Generation by Fuel: 1999 to 2020



Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.101.

The forecast growth in renewable electricity supply largely reflects expectations about the impact of the Mandated Renewable Energy Target (MRET) established by the Commonwealth Government. The MRET scheme commenced on 1 April 2001. The *Renewable Energy (Electricity) Act 2000* requires the generation of 9500 gigawatt hours of extra renewable electricity a year by 2010. This target was established in order to increase the share of electricity generated by renewable sources by approximately 2 percentage points. The Office of the Renewable Energy Regulator has been established to supervise implementation of the measure.[6]

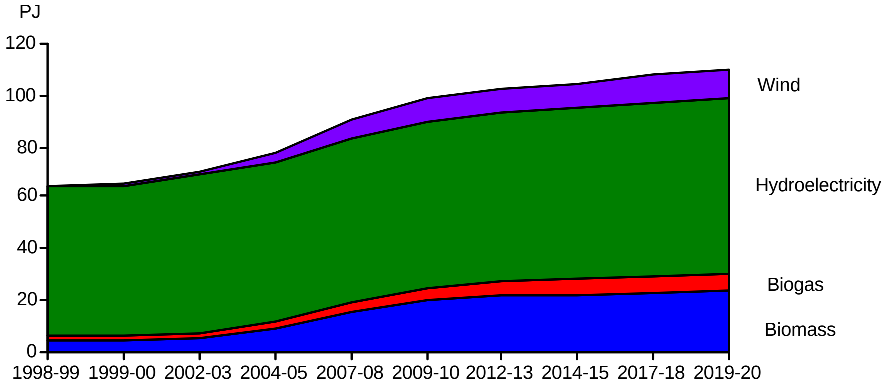
It is important to note that the intention of the measure was not to reduce greenhouse gas emissions (although it does have that effect), but specifically to give renewable energy options a foothold into the energy market. A review of the efficiency and effectiveness of the measure is outside the scope of this report.

6 See the Regulator's website for further information about the measure at www.orer.gov.au.

The Commonwealth Government also provides funding to support the renewable energy industry.[7]

Figure 3.6 separates the specific renewable technologies contained within the renewables category in the figure above. The figure reveals the continuing large share of hydro in Australia's renewable electricity generation task and the strong forecast growth in biomass and wind generation, albeit from a low base in the case of the latter.

Figure 3.6: Australian Renewable Electricity Generation by Fuel: 1999 to 2020



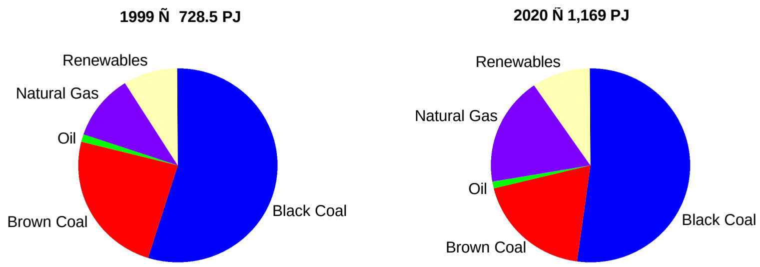
Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.101.

Figure 3.7 shows the change in shares of electricity generation by fuel between 1999 and 2020. The data indicates that the share of:

- black coal will fall slightly from 54.8 to 52.3 percent;
- brown coal will fall markedly from 24.5 to 18.8 percent;
- oil will continue its minor role increasing from 1.1 to 1.2 percent;
- natural gas will increase significantly from 10.7 to 18.3 percent; and
- renewables will increase slightly from 8.9 to 9.5 percent.

7 Programs include the Renewable Remote Power Generation Program (RRPGP), the Photovoltaic Rebate Program and funding for renewable energy commercialisation and industry development.

Figure 3.7: Shares of Australian Electricity Generation by Fuel: 1999 and 2020

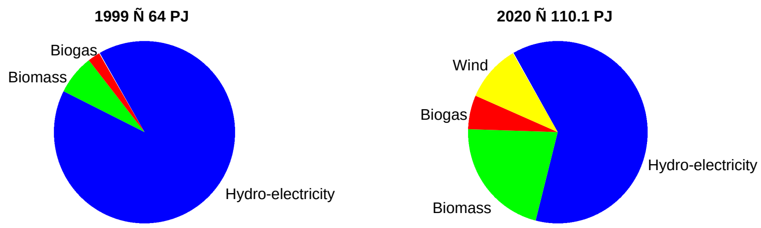


Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.48.

Figure 3.8 shows the change in shares within the renewables sector. According to ABARE's projections, between 1999 and 2020, the share of:

- wind will increase from negligible levels to 1 percent;
- hydro will fall from 8.1 to 5.9 percent;
- biogas will increase from 0.2 to 0.6 percent; and
- biomass will increase from 0.6 to 2 percent.

Figure 3.8: Shares of Australian Renewable Electricity Generation by Fuel: 1999 and 2020



Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.48.

Average annual growth rates for the data shown in Figures 3.3 and 3.4 are shown in Table 3.2.

Table 3.2: Australian Electricity Generation by Fuel ¾ Average Annual Growth: 1999 to 2020

Fuel	Ave Annual Growth
Black Coal	2.1
Brown Coal	1.0
Oil	2.6
Natural Gas	4.9
Hydroelectricity	0.8
Biomass	8.1
Biogas	7.5
Wind Energy	25.2
Total	2.3

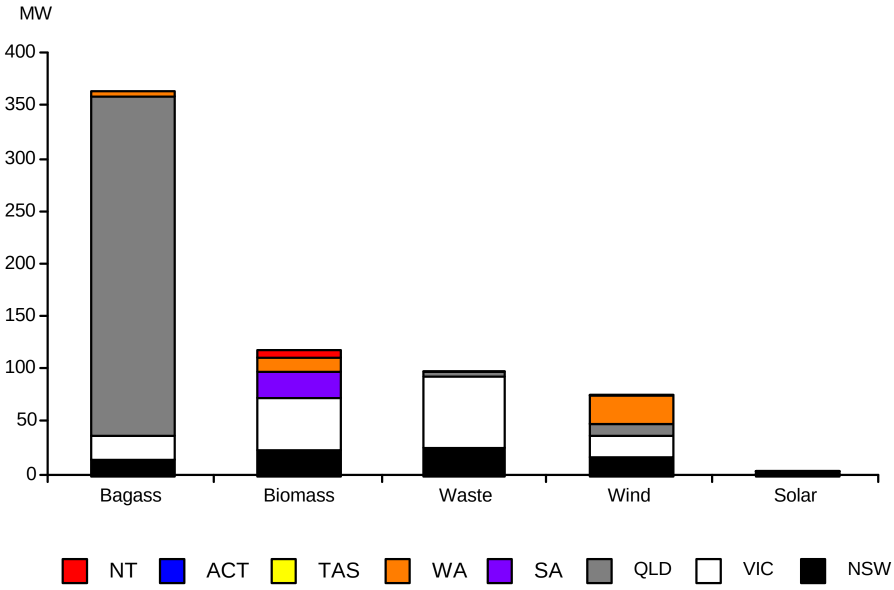
Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.48.

The table shows that growth in coal and hydro will be below the average of 2.3 percent while natural gas and renewables will be higher. Wind grows most strongly, reflecting its low base, while biomass and biogas also grow strongly at more than three times the average rate of growth.

Figure 3.9 gives an insight into the current location of renewable energy production in Australia. The figure shows the:

- strong presence of bagasse generation in Queensland;
- high proportion of biomass and other waste generation in Victoria; and
- fairly even spread of wind generation across NSW, Victoria, Queensland and Western Australia (however, this picture is rapidly changing with Victoria and particularly South Australia showing much stronger growth in terms of future capacity).

Figure 3.9: Capacity of Renewable Generation by State (30 June 2001)

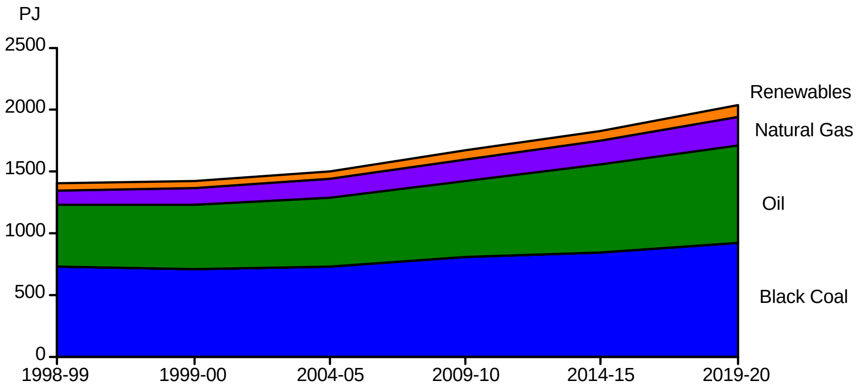


Source: Electricity Supply Association of Australia, *Electricity Australia 2002,* p.31.

3.5 New South Wales — Projected Energy Consumption

Figure 3.10 focuses on projected primary energy consumption by fuel in NSW. The figure shows the continued gradual increase in the consumption of energy from black coal and oil and a slightly higher increase from natural gas and renewables.

Figure 3.10: NSW Primary Energy Consumption by Fuel: 1999 to 2020

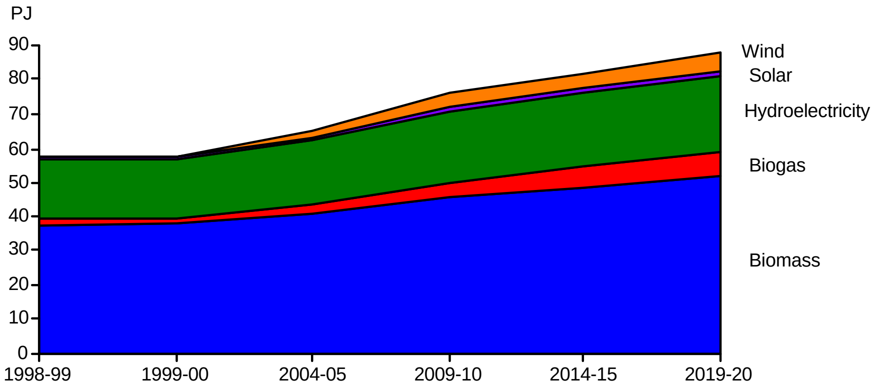


Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.91.

Figure 3.11 highlights what is happening within the renewables sector. The data shows that, over the period to 2020, it is projected that:

- biomass will grow steadily and continue to account for more than half of NSW's renewable energy consumption;
- biogas will grow relatively strongly but from a low base;
- consumption of hydroelectricity will remain broadly the same;
- consumption of solar energy will increase gradually from a low base; and
- wind will increase fairly strongly but also from a low base.

Figure 3.11: NSW Primary Renewable Energy Consumption by Fuel: 1999 to 2020



Source: Australian Bureau of Agricultural and Resource Economics, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, October 2001, p.91.

3.6 Conclusion

The Australian renewable energy supply industry has grown rapidly from a low base. Clusters of expertise and scale are beginning to form in different states, with promising expectations for biomass and wind, which is expected to grow at very rapid rates in coming years. Biogas also is set to grow more rapidly than the average for the electricity supply industry at large.

The growth experienced to date and the forecast reflects policies adopted by governments to support renewable energy. Policy positioning is crucial at this stage in the SEI's development.

4 Competitiveness

Renewable electricity supply and the sustainable energy industry in general face significant challenges to competitiveness at present reflecting market failure, regulatory failure and infant industry cost structures. As a result, renewable electricity is currently more expensive than traditional supply options.

This chapter reviews the nature of the gap in prices and competitiveness between renewable energy and traditional fossil fuel based options. It also reviews recent data from overseas and within Australia suggesting trends towards the gap being closed rapidly in some renewable electricity generation activities.

While the gap is closing, support for the renewable electricity supply activity is likely to impose a cost upon the community. Further chapters set out how transition costs can be mitigated through concerted policy action.

4.1 Competitiveness of Renewable Technologies

A key factor limiting the uptake of renewable energy is the cost of electricity production compared to traditional fossil fuels.

Generation costs for five renewable energy technologies estimated in the SEDA *Distributed Energy Solutions* compendium are set out in Table 4.1. This data suggests that while some renewable technologies are of comparable cost or approaching competitiveness with fossil fuel generation, others are significantly less competitive. However it is important to note that these generation costs do not factor in cost offsets such as Renewable Energy Certificates, Green Power premiums and avoided waste disposal costs.

Table 4.1: Renewable Technology Generation Costs

Technology	Average Generation Cost (c/KWh)
Wind	11.9
Solar PV	73.5
Biomass (wet)	8.6
Biomass (dry)	6.1
Tidal and Wave	17.3

Source: SEDA, *Distributed Energy Solutions*, February 2002, p.43.

Another source of information comparing renewable technologies with Queensland black coal generation is presented in Table 4.2.

Table 4.2: Alternative Renewable Technology Generation Costs

Technology	Generation Cost (c/KWh)
Black Coal: South Qld	3.5
Cereal Residues	11.8
Forestry Residues	12.2
Sawmill Waste	5.3-9.5
Plantation Thinnings	11.3
Wind: Tasmania	10.8
Wind: Victoria	12.6
Wind: Lake Carcour NSW	11.3

Source: Redding, G, *Renewable Power Production*, March 2001, p.7.

While estimates differ, the broad conclusion that can be drawn is that renewable technologies are at present not competitive with fossil fuel generation the costs of which are around the 3-4 c/KWh mark. However, over time, there is evidence (discussed below) that advancement in renewable technologies is expected to close the gap with fossil fuel generation.

While not reflected in the table above, it should be noted that potentially significant economic benefits accrue where renewable generation technologies are 'embedded' in the distribution network (as is typically the case). This is because investment in transmission and distribution network capacity augmentation is avoided or deferred. For example, solar cells on the roof of a house generate energy for use onsite, minimising the need for capital-intensive network capacity and avoiding losses associated with the transmission and distribution of energy. Generation costs per unit of delivered energy should be seen in this wider context.

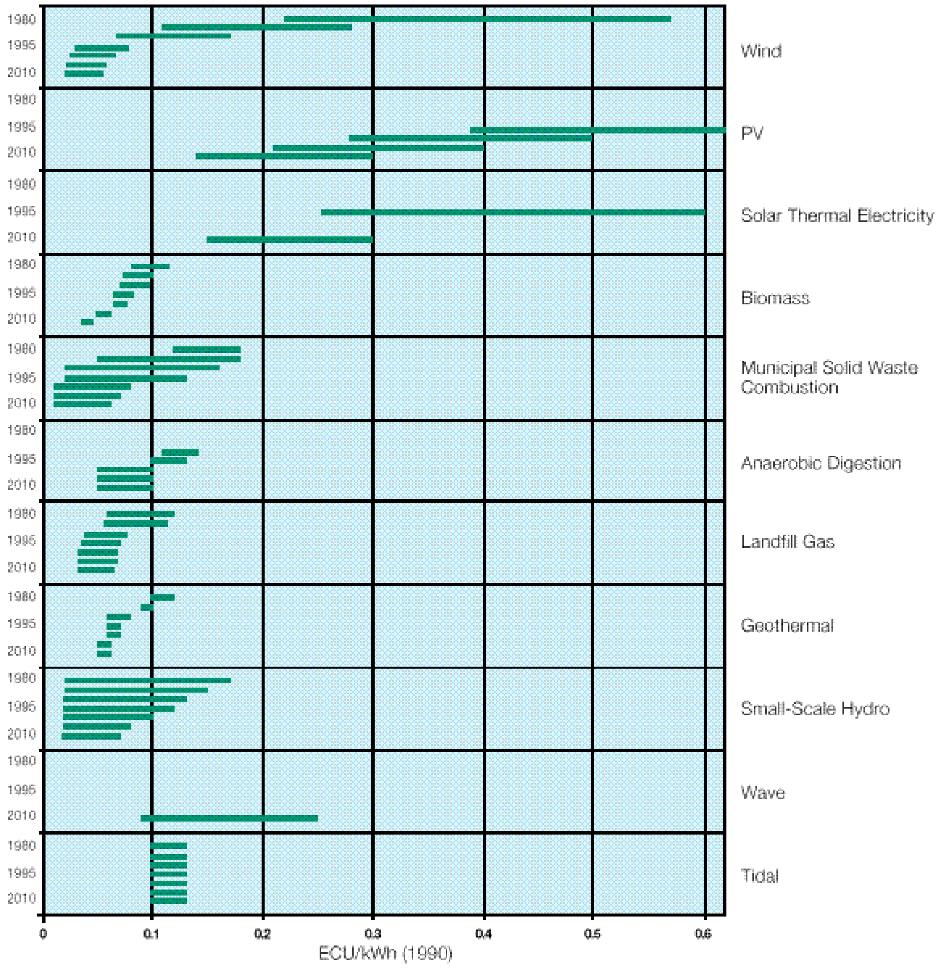
Figure 4.1 shows costs for differing renewable energy options over the period since 1980 with projections out to 2010. The prices are reflected as horizontal bars reflecting the range evident in differing countries and regions. Overall, the figures illustrate significant anticipated cost reductions in relation to:

- wind;
- photovoltaic cells; and
- solar thermal electricity.

Cost reductions are also forecast in technologies that already have relatively low costs but for which further improvement is expected, including:

- biomass;
- municipal solid waste combustion;
- small scale hydro; and
- landfill gas.

Figure 4.1: Historical and Future Costs of Electricity Produced by Renewable Technologies

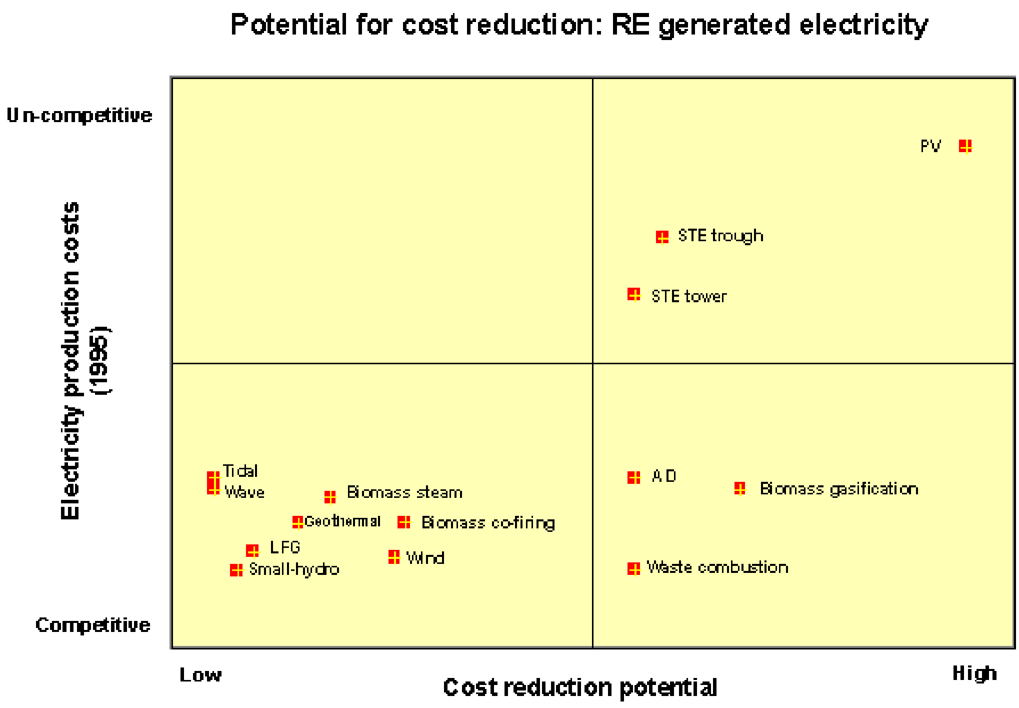


Source: Renewables Overview – Key Technologies at http://europa.eu.int/comm/energy_transport/atlas/htmlu/rover31.html on 26 August 2002.

Figure 4.2 maps both the current competitive position and the scope for cost reduction for the electricity and heat producing renewable energy technologies. The analysis measures renewable energy technologies in terms of their current costs and their potential for future cost reduction. The analysis suggests that:

- some renewable technologies are relatively mature like landfill gas, hydro and heat production through biomass gasification. These technologies are already approaching cost competitiveness in their own right;
- some are less mature, like PV, solar thermal electricity and direct conversion of biomass to electricity. These are not currently competitive with bulk power, but have significant potential for further cost reduction; and
- other renewable technologies, for example tidal energy and liquid biofuels, seem to have little scope for further cost reduction through improvement in the technology.

Figure 4.2: Competitive Position of Electricity Producing Renewable Technologies (based on their 1995 energy production costs and their potential for cost reduction to 2010)



Source: Renewables Overview – Key Technologies at http://europa.eu.int/comm/energy_transport/atlas/htmlu/rover33.html on 26 August 2002.
Note: STE stands for Solar Thermal Electricity, AD stands for Anaerobic Digestion, and PV stands for Photovoltaic

Table 4.3 sets out data on the projected generation cost of renewable technologies in 2020. Compared to the cost of fossil fuel generation reported in Figure 4.1, the data suggests that a large range of renewable technologies will approach competitiveness with coal and gas over the medium term.[8]

[8] These figures were developed in the UK, hence, for some technologies, costs may not be applicable to Australia due to different costs, availability and quality of resources (eg, wind speed, biomass fuel costs). However, as the key cost driver for renewable generation is the efficiency of the technology, the figures are indicative of the likely future cost of renewable generation.

Table 4.3: Projected Generation Cost of Renewable Technologies in 2020

Technology	2020 Cost[a] (c/KWh)	Basis for Assessment	Confidence in Estimate	Cost Trends to 2050
End use efficiency	Low[9]	Engineering assessment	High	Decrease, but variable[10]
Fuel Cells	Unclear	Engineering assessment	NA	Sustained decrease
Large Combined Heat and Power (CHP)	Under 6	Engineering assessment	High	Limited decrease
Micro CHP	7 – 10	Engineering assessment	Moderate	Sustained decrease
Transport Efficiency	Low	Engineering assessment	NA	Unclear – fuel switching
PV	28 – 44.5	Learning rate and market growth rate	High	Sustained decrease
Onshore Wind	4 – 7	Learning rate and market growth rate	High	Limited decrease
Offshore Wind	5.5 – 8	Engineering assessment and onshore learning rate	Moderate	Decrease
Energy Crops	7 – 11	Engineering assessment and learning rate	Moderate	Decrease
Wave	8–16.5	Engineering assessment	Low	Uncertain
Fossil Generation with CO_2 C&S	8–12.5	Engineering assessment	Moderate	Uncertain
Nuclear	8 – 11	Engineering assessment	Moderate	Decrease
Combined Cycle Gas Turbine	5.5 – 6.4	Engineering assessment and learning rate	High	Limited decrease
Coal (Integrated Gasification Combined Cycle)	8 – 10	Engineering assessment	Moderate	Decrease

Source: UK Cabinet Office, *The Energy Review*, A Performance and Innovation Unit Report, February 2002.
Note: (a) means costs converted from UK pounds at a rate of A$1=36p.

In the Australian context, a range of estimates has been developed of the future cost of renewable technologies. One such set of estimates is set out in Table 4.4. The figures suggest that renewable technologies are generally not competitive with fossil fuels and this will not change significantly by 2010. Although, as noted, it is important to consider forecast generation costs in the wider context of avoided transmission and distribution costs.

9 Energy Efficiency measures are usually cost effective and therefore the cost of saving energy is below the cost of supply to the relevant final user.

10 Costs of individual technologies are expected to decrease with innovation, but much of the lowest cost potential will progressively be deployed.

Table 4.4: Alternative Renewable Technology Generation Costs (c/KWh)

Technology	2000	2010
Black Coal: Sth Qld	3.5	3
Cereal Residues	11.8	9.9
Forestry Residues	12.2	10.3
Sawmill Waste	9.5	8.7
Plantation Thinnings	11.3	9.4
Wind: Tasmania	10.8	7.6
Wind: Victoria	12.6	8.5
Wind: Lake Carcour NSW	11.3	7.4

Source: Redding, G, *Renewable Power Production*, March 2001, p.7. (renewables); Redding, G, *Outlook for Green Power Generation in Australia*, December 2001, p.9 (coal 2000); The Allen Consulting Group estimate (coal 2010).

Despite existing disparities in costs structures between renewable energy and other sources, governments around the world are taking unilateral and multilateral action to address widespread concerns about the sustainability of unadjusted energy market outcomes. While many countries are still giving consideration to broad measures to address the threat of climate change posed by greenhouse gas emissions, a large number have already implemented policies intended to give renewable energy a foothold in energy markets. Given the cost differential against renewable energy technologies that prevails at present, this is a more expensive approach than allowing market forces to play out fully. Governments in many countries appear to be acting on the basis of maintaining a range of energy market options as a means of managing risk and uncertainty about the future and they appear to essentially view the additional costs as the equivalent of an insurance premium.

It is as if policy makers are taking this approach because it reflects uncertainty about the long term cost of carbon, the value of abating pollution, and the long term costs of greenhouse gas abatement. These broad elements of uncertainty point to possible far-reaching changes in the competitive advantage of the energy sector. Governments appear to be bearing the additional costs of renewable energy as an insurance premium that can be seen as a hedge against long term energy market uncertainty, which could have the result of making carbon intensive economies less competitive. Governments also appear to be acting on the notion that there is a benefit from learning by doing.

4.2 Renewable Technologies: Competitiveness Case Studies

4.2.1 Achieving Competitive PV Performance

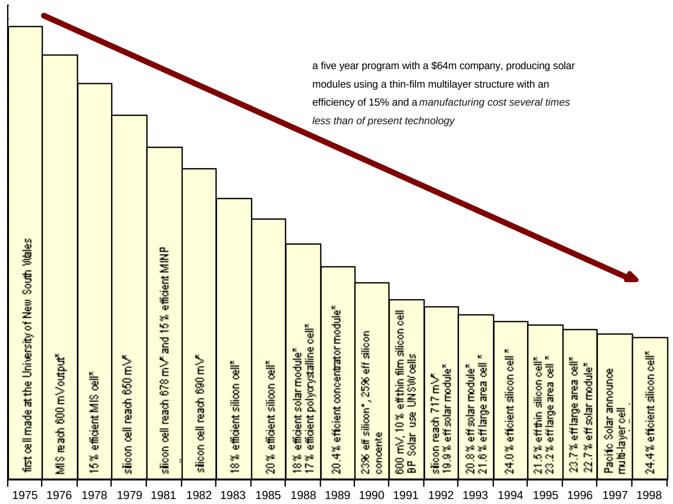
The Photovoltaics Special Research Centre was established at the University of New South Wales in 1990 with founding grants from the Australian Research Council and Pacific Power. Professor Martin Green, who began developing solar cells at UNSW in the mid-1970s, heads the group. Growing interest in sustainable technologies has spurred the growth of the group, which now has about 70 staff and students.

The main researches at the Centre are high efficiency solar cells, buried contact solar cells, thin film solar cells, and photovoltaic systems. Nearly all device research is based on the semiconductor silicon. Systems research areas investigated include static concentrator roof tiles, inverters (interface DC output of solar cells with AC systems), grid connection, site selection, remote area power supplies, institutional issues and building integration.

Major successes include buried contact solar cells licensed to most of the world's major solar cell manufacturers such as BP Solar and Pacific Solar. The five-year program of this $64 million company is to develop commercial solar modules using a thin-film multi-layer structure, with an efficiency of 15 percent and a manufacturing cost several times less that of present technology. The Centre also had success in solar car races such as the World Solar Challenge.

Since the Centre’s laboratories began their research in 1974, many important results have been achieved. Some of the milestones achieved are presented in Figure 4.3.

Figure 4.3: Achievements by the Centre for Photovoltaic Engineering UNSW



Source: http://www.pv.unsw.edu.au/info/pvceinfo.html
Note: * indicates World first

4.2.2 Coal Seam Methane Opportunities

There is strong potential to export methane-reducing technologies using Waste Coal Mine Gas to countries such as the USA, China, Russia and other former Soviet countries. The Australian market for these technologies is estimated at up to 400MW (or $800M in investment)[11]. Australia represents under 5 percent of the world waste coal mine gas resource, meaning a potential world market of something like 15,000MW or $30 Billion in investment (237 Mt/y of CO_2 equivalent GHG emissions worldwide).[12]

Several Australian companies are developing new technologies to use low methane Mine Ventilation Air. These include:

- CSIRO (the Calorific Gas Turbine, and the Rotary Kiln);

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11 SEDA expert estimate based on consultation with wide range of industry sources.

12 US EPA website www.epa.gov

- Energy Developments Ltd. (the Carburetted Gas Turbine); and
- BHP Billiton (the Megtech Vocsidiser).

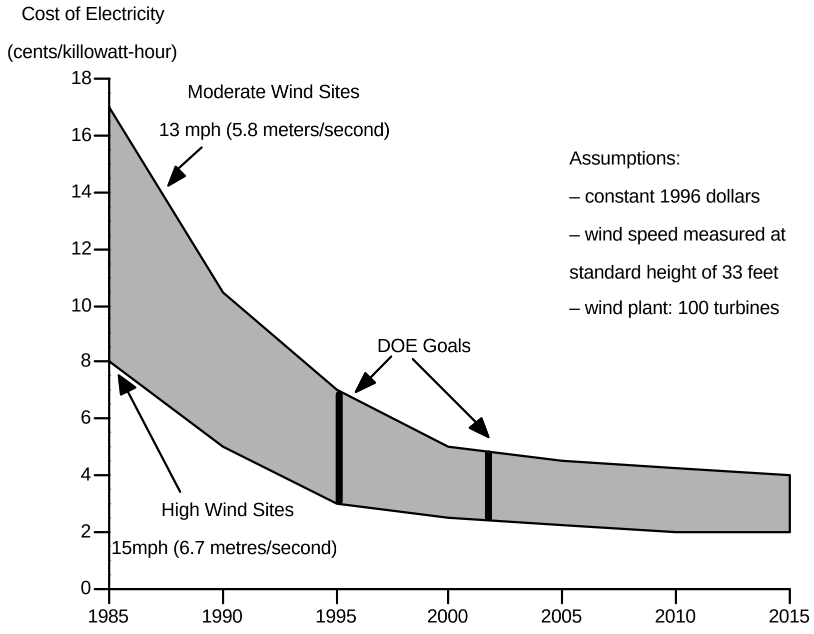
These technologies are considered leading edge, with little competition internationally, and hence there is significant export potential, if the market is developed to address niche demand. In addition, Australian companies such as Envirogen and Energy Developments are focusing on more traditional methods of power generation from the richer mine drainage gas, and would also be able to win projects internationally if the market were developed.

4.2.3 Assessing the Efficiency of Wind

Cost structures and anticipated efficiencies vary widely across renewable technologies. Wind energy is already one of the most cost-competitive renewable energy technologies. Wind is therefore a natural case study for understanding maturing cost dynamics. Regardless of progress in cost performance, wind-generated electricity still costs more than electricity from natural gas or coal fired power plants. However, R&D initiatives about the wind turbine of the future suggest the gap is soon to close, providing low-cost electricity for homes, businesses, schools, manufacturing plants, and the like. Low-cost turbines are expected to open up a major market for wind energy in the large countries with suitable landscapes such as Australia, Canada, and the United States. Figure 4.4 shows the reduction in the generating cost of wind over time.

WindLite Corporation formed in 1996. WindLite Corporation is developing an 8-kW, variable-speed, direct-drive machine with a rotor diameter of 7 metres. The turbine uses a wound-rotor generator and proprietary controller that significantly increases its battery-charging efficiency compared to permanent-magnet generators. The projected Cost/Performance Ratio for the WLC 7.5 is $0.46/kWh. DOE is providing $1,430,901 in funding.

Figure 4.4: Cost of Wind Energy



Source: US DOE Wind Energy Program

The US government has captured cost reductions in US developed technology by focusing its mid-1990 efforts to achieve cost/performance improvements pictured in the above graph. Initiatives were designed to develop:

- large, utility-scale turbines;
- small turbines for rural or remote areas; and
- advanced new turbine components.

These initiatives have succeeded in pushing out the price/performance parameters of wind considerably.

DOE-funded US Sandia National Laboratories strives to lower the cost of turbine rotors by working with industry to improve manufacturing processes, shorten the time it takes to cure the blades, and make other improvements, researchers hope to reduce the blade costs by as much as 25 percent. Sandia also works with industry and academia to improve blade-manufacturing processes for fibreglass and plastic blades.

However, improvements in performance extend beyond technology. Indeed, to foreshadow the following chapter on Learning Curves, 'learning by doing' is a crucial element in achieving first mover advantage. The UK Cabinet Office's recent energy review suggests that:

> "The main alternative method is to use experience curves, based on 'learning-by-doing'. They are widely used in business, but have not been used extensively for the assessment of UK energy policy. Evidence from a very wide range of technologies and sectors demonstrates a clear relationship between production and cost; put simply, as cumulative production increases, costs fall. This is not to underplay the complexity of the drivers of cost reduction — technological innovation, economies of scale, improved utilisation of labour and capital, etc. — but *the conclusion is that most learning and cost reduction come through production and market experience*."[13]

Reflecting the need to learn by doing to be competitive in the SEI industry, New South Wales would have to stimulate learning opportunities that reach across all segments of the value chain, including:

- technologies for producing renewable energy;
- project management spanning financial modelling, community engagement, and regulatory interface;
- mapping and siting;
- training and safety management;
- marketing and customer relationship management;
- complaints management; and
- certification.

Industrial products typically have a "learning range" of between 10 and 30 percent — this means that for each doubling of cumulative production, there is a drop in costs of between 10 and 30 percent.[14] Markets for renewable technologies are global, so world production is a more relevant factor than NSW production alone. But applying technologies to local conditions will also impact on the learning curve.

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13 UK Cabinet Office, *The Energy Review A Performance and Innovation Unit Report*, February 2002. (emphasis added)

14 UK Cabinet Office, *The Energy Review A Performance and Innovation Unit Report*, February 2002. Annex 6, p.2.

Three conclusions are emerging about renewable technologies and their ability to become more competitive:

- technologies with a small share tend to have more potential for cost reduction;
- if established technologies are allowed to, they can exclude alternatives that would be cheaper in the longer term; and
- as experience grows, there is less uncertainty about potential cost reductions.

4.3 Economic Efficiency Through Demand Management

"To achieve improved scenario development, it will be necessary for greater independence to be introduced into energy planning, otherwise the fatalistic process of supplying demand rather than reducing demand, will continue."

Total Environment Centre submission to IPART DM Inquiry 2001

A competitive energy sector for NSW requires the efficient delivery of energy services within a regulatory framework that gradually attributes costs to carbon intensity. As IPART's Interim Report on its inquiry into demand management identified, Demand Management (DM) can play an important role in driving competitiveness in NSW energy markets:

> "The various DM options can deliver a range of benefits, including financial benefits, such as improved utilisation of generation, transmission and distribution assets; reduced peak demand pressures on various rated capacities of networks; deferral of capital investments and lower costs for end-users; environmental benefits; and social benefits such as lower energy costs for end-users. These benefits are diverse, and flow to more than one sector of the economy, either directly through reduced costs, or indirectly through environmental benefits."[15]

The UK Cabinet Office recently commissioned an energy review[16] which reached conclusions similar to IPART's regarding the economic benefits of DM. Domestic sector data in the UK confirms that existing regulatory programs are highly cost-effective[17], saving electricity at 22 percent of the purchase price (and under half the avoidable cost of supply). Business sector energy efficiency programs have a payback period of between 2 and 4 years, and are now estimated to save over £800 million annually.[18] The potential financial benefits in lower costs to UK industrial and residential consumers are £12 billion annually, net of taxes.

Given similar commercial returns it is likely that the NSW economy would benefit greatly from more vigorous DM strategies. The environmental contribution would be just as significant, not only in terms of reduced greenhouse gas emissions but also reduced impacts on regional air quality, land use and water quality (eg, from coal mining). Competitiveness in renewable energy production and distribution is just as important as effective DM strategies, in terms of maximising investment and employment options for the NSW SEI sector, particularly in the longer term.

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15 IPART, *Interim Report ¾ Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, April 2002, p. 8.

16 UK Cabinet Office, *The Energy Review A Performance and Innovation Uni Report,* February 2002, Annex 6.

17 See National Office Audit, 1998.

18 UK Cabinet Office, *The Energy Review A Performance and Innovation Uni Report,* February 2002, Annex 6, p. 4.

4.4 Conclusion

Given correction of market and regulation failures or equivalent offsetting support and the opportunity to 'learn by doing' the SEI can become cost competitive with traditional fossil fuel energy options in time.

For some years to come, however, gaining competitive positioning in the growing renewable energy sector, requires active promotion of SEI technologies, both at technical and project levels.

Because the best way to learn about SEI technologies and to be competitive is to practice their application, jurisdictions that do not engage in supporting their development and application now will be at a disadvantage later.

5 The Development of Sustainable Energy Technologies

In this chapter we explore the dynamics of improving SEI price/performance yields. Normal technological dynamics are reducing carbon intensity but at a rate that is slower than the rise in demand for carbon based fossil fuels. Currently, most environmentally friendly energy technologies are still too expensive to compete with fossil technologies in present markets. However, cost barriers may be reduced through understanding learning curves and the need for learning investments.

5.1 Technology Change

Improvement in technological knowledge is the most important single factor that contributes to long-term productivity and growth.[19] Even small technological changes can have radical impacts when compounded over time, which is why many look to the impact of technology upon the development of the SEI. Technology change can be signposted by six stages:

- *invention* — the first stage, represents the creation of an idea;
- *innovation* — the second stage represents the application of an invention;
- *niche market commercialisation* — the third stage, is where the useful aspects of the new technology are employed in niche markets;
- *pervasive diffusion* — the fourth stage, occurs as a wider array of markets follow the example set by the niche markets and adopts the technology;
- *saturation* — the fifth stage, occurs when market growth is exhausted; and
- *senescence* — the final stage, occurs when a new competitor takes market share or redefines performance requirements.[20]

These stages and their typical characteristics are shown in Table 5.1.

[19] Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

[20] Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

Table 5.1: Stylised Stages of Technological Development and Typical Characteristics.

Stage	Mechanisms	Cost	Commercial Market Share	
Invention	Seeking and stumbling upon new ideas; breakthroughs; basic research	High, but difficult to attribute to a particular idea or product	0percent	"Radical"
Innovation	Applied research, development and demonstration (RD&D) projects	High, increasingly focused on particular promising ideas and products	0percent	
Niche market commercialisation	Identification of special niche applications; investments in field projects; "learning by doing"; close relationships between suppliers and users.	High but declining with standardisation of production	0-5percent	"Incremental"
Pervasive diffusion	Standardisation and mass production; economies of scale; building of network effects.	Rapidly declining	Rapidly rising (5-50percent)	
Saturation	Exhaustion of improvement potentials and scale economies; arrival of more efficient competitors into market; redefinition of performance requirements	Low, sometimes declining	Maximum (up to 100percent)	"Mature"
Senescence	Domination by superior competitors; inability to compete because of exhausted improvement potentials	Low, sometimes declining		

Source: Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

Note: Also shown, in the right column, are three terms often used when classifying technologies that are marked by substantially different relative performance at a given moment in time.

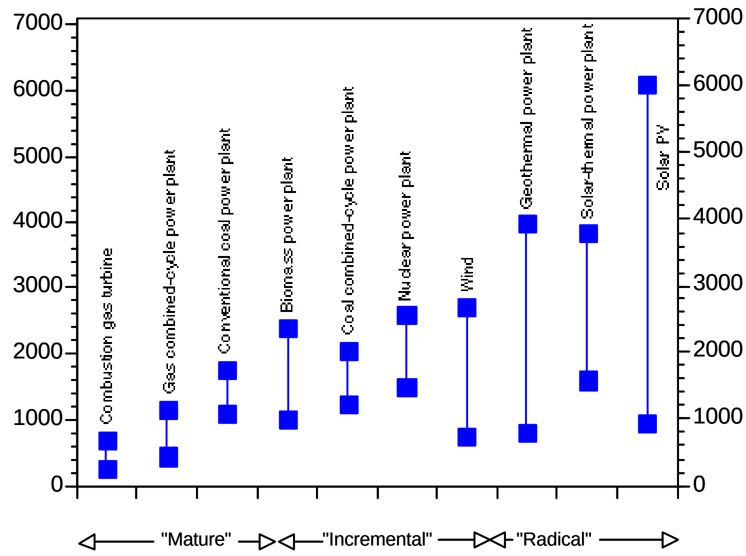
The stages reflect that the evolution of technology is a competitive process dominated by market forces. Firms invest in new technologies in their pre–competitive states, even though they have no commercial market share, hoping for later returns.

Once competitive, the interplay of performance and costs determines market share. Consequently, performance, costs and market share are used to measure a technology's stage of development. For example, less costly technologies which are in the pervasive diffusion and saturation stages, such as conventional fossil fuel electricity generating plants, have a greater market share than those found only in niche markets, such as photovoltaic cells. However, technologies in the niche market stage will move to the pervasive diffusion stage and further when performance requirements change. For example, new requirements to remove and dispose of $C0_2$ from flue gases would double or triple the costs of conventional fossil fuel-electricity plants but leave largely unaffected the cost of solar, wind and biomass-based energy generation thus substantially increasing their competitiveness.[21]

Much of technological analysis for purposes of assessing environmental effects is aimed at examining which new (radical and incremental) technologies will achieve what speed and level of penetration in commercial markets.

Figure 5.1 shows the current cost of selected electricity generating technologies and categorises them according to their current position in the technology development stages previously described. Technologies that are viewed as having reached pervasive diffusion are labelled ‘mature’ technologies. These technologies have stable performance and costs and include conventional coal power plants. Niche market technologies are labelled ‘incremental’ technologies, as they are more costly than mature technologies but offer some performance advantage and the potential for significant cost reduction with continued investment. Technologies in this bracket include biomass power plants and wind technology. The ‘radical’ technology group represents technologies in the innovation stage where there is greater uncertainty as to the potential for improvement and their application to the commercial market place. However, radical technologies also offer potential radical improvements in both performance and cost — often by a factor of 10 or more.[22]

Figure 5.1: Electricity Generation Technologies: Technology Development Phases



Source: Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

21 Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

22 Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

5.2 Learning Curves, Costs and Sustainable Energy Technologies

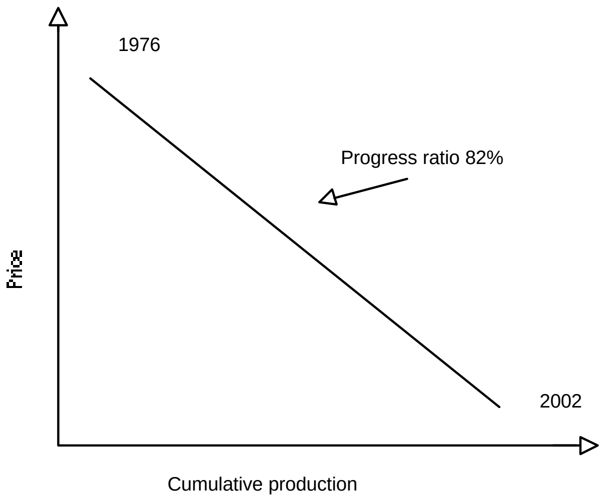
Improvement in costs and performance due to 'learning' (at the individual level, at the organisational level, or through economies of scale) is one of three key attributes that drive the technological change of energy technologies. The other key attributes important in the shift toward more sustainable energy technologies are:

- dynamic competition between technologies; and
- network or cluster effects and technological interdependence.[23]

Learning Curves are widely used tools for production and strategic analysis within levels of technology-intense industries and are increasingly being applied to energy technologies. Central to the learning curve phenomena is that by gathering market experience, individuals, enterprises and industries do better, providing a quantitative relationship between price and the cumulative production or use of a technology. That is, there is improvement in both cost and performance due to cumulative experience and investments.

Learning curves, also known as 'experience curves', typically show the decline in unit costs of production as experience is gained. Because learning is a function of actual experience rather than the passing of time, learning curves usually take the form of a power function where unit costs decrease exponentially as a function of cumulative output — see Figure 5.2.

Figure 5.2: Schematic Representation of a Learning Curve



Source: The Allen Consulting Group

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23 Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

The slope of the learning curve, known as the 'learning rate', is the percentage decline in costs per doubling of accumulated experience. The corresponding change in price is known as the 'progress ratio'. The learning curve in Figure 5.2 has a progress ratio of 82 percent, meaning that price is reduced to 0.82 of its previous level after a doubling of cumulative sales. The learning rate is 100 minus the progress ratio. Thus, in the figure, the learning rate for PV modules in the period 1976-1992 was 18 percent (ie, 100-82), meaning that each doubling of sales reduced the price by 18 percent.

Learning rates vary substantially between technologies at different stages as demonstrated in Table 5.2. Learning rates are greatest with technologies in their early stages of development (when in the radical stage) and are typically around 50 percent. Learning rates fall once a technology moves into the incremental phase, often to 10 – 40 percent, and fall even further, typically to 10 percent, when they reach maturity.

With the fall in learning rates, the potential for cost reduction is also reduced as the technology matures and maximum commercial market share is achieved. This occurs because young technologies learn faster from market experience than old technologies with the same progress ratio meaning that the same absolute increase in cumulative production has a much more dramatic effect at the beginning of a technology deployment than it does later on. So for well established technologies in established markets, such as coal plants using conventional technology, the experience effect is hardly noticeable.

Table 5.2: Learning Rates According to Technological Development Stages

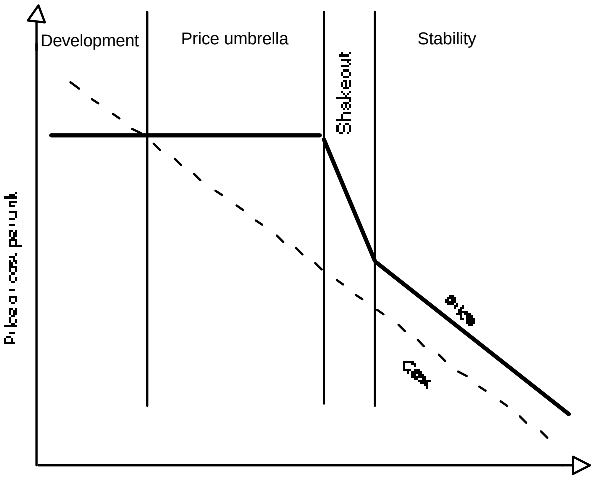
Stage	Commercial Market Share	Learning Rate	
Invention	0percent	Unable to express in conventional learning curve	"Radical"
Innovation	0percent	High perhaps > 50percent)	
Niche market commercialisation	0-5percent	20 – 40percent	"Incremental
Pervasive diffusion	Rapidly rising (5-50percent)	10-30percent	
Saturation	Maximum (up to 100percent)	0percent (sometimes positive due to severe competition)	"Mature"
Senescence		0percent (sometimes positive due to severe competition)	

Source: Grubler, A, Nakicenovic, N and Victor, D, *Dynamics of energy technologies and Global Change*, Energy Policy 27, 1999, pp.247 – 280.

Learning curves help highlight the dramatic reduction in costs evident in the early stages of technology development from innovation through to initial diffusion into widespread application. Learning curves also help identify technologies that might become competitive with adequate investment and can be used to assess the future prospects of environmentally friendly technologies and the policies required to stimulate them into commercial production.

Once a technology has become commercially viable it enters a price cycle dominated by four phases.[24] These phases are depicted in Figure 5.3. In the development phase, the producer sets prices below cost to establish a market. Once cumulative output of the product increases and the technology moves along the learning curve, cost falls below price. As a market leader, the producer is able to maintain price above cost creating a price umbrella that remains until other competitors enter the market. The progress ratio at this phase is typically 90 percent or more.[25] The market then enters the shakeout phase when prices fall faster than costs reflecting increased producers in the market and the influence of competition. Progress ratios in this phase are typically 60 percent.[26] The shakeout phase is unsustainable though as prices cannot stay below cost so prices stabilise in the last phase around an experience curve that has the same progress ratio as the cost curve.

Figure 5.3: Price-Cost Relations for a New Product



Source: International Energy Agency, *Experience Curves for Energy Technology Policy*, OECD/IEA, 2000.

5.3 Application of Learning Curves to Energy Policy

Increasingly attention is being placed on how learning curves can be used to strengthen energy technology policy analysis and decision-making. Despite wide use in industry,

24 International Energy Agency, Experience *Curves for Energy Technology Policy*, OECD/IEA, 2000.

25 International Energy Agency, *Experience Curves for Energy Technology Policy*, OECD/IEA, 2000.

26 International Energy Agency, *Experience Curves for Energy Technology Policy*, OECD/IEA, 2000.

experience curves are seen to be currently under-utilised in public policy analysis.[27] An IEA workshop, *Experience Curves for Policy Making — The Case of Energy Technology*, held in Germany in 1999 observed that:

> "Experience curves provide the policy analyst with a tool to explore technology and policy options to support the transformation of energy systems and markets towards sustainable development…[experience curves] help to clarify the potential benefits of deployment programmes and market transformation programmes… [and can help] identify low cost paths to CO2 stabilisation by the middle of the next century".

The workshop also observed that to increase the application of learning curves to the development of energy policy, databases were required to provide more readily available information to government decision makers and that the methodology needed to be further developed.[28] However, learning curves allow policy makers to determine what investment is required to promote more competitive sustainable energy technologies. Box 5.1 provides an example of policy considerations made with a PV learning curve.

When used, learning curves are generally central to the rationale behind technology development and deployment policies, which assist in overcoming price barriers and encourage technology learning. Research, development and demonstration (RD&D) and deployment policies are vital to the improvement of performance and the lowering of costs in the early stage of technological development. However, it is important to note that the OECD considers that investment in RD&D and 'learning investment' fulfil different needs when applied to the development of energy technologies.[29]

Whereas public RD&D spending can initiate and support the initial stages in developing a new technology investment, deployment programs are required once a technology appears marketable. Deployment programs provide resources for learning activities through promoting actual production and are thus seen as the dominant resource for the later stages of technology development where the objectives are to overcome cost barriers and make the technology commercial. Technologies cannot become cost effective by laboratory R&D alone.

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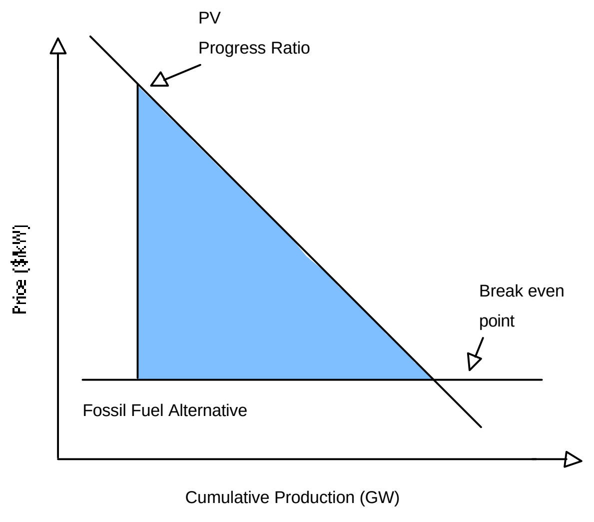
27 UK Cabinet Office, *The Energy Review A Performance and Innovation Unit Report*, February 2002.

28 International Collaboration on Experience Curves for Energy Technology Policy, Paris 15 October 1999 at http://www.iiasa.ac.at/Research

29 International Energy Agency, *Experience Curves for Energy Technology Policy*, OECD/IEA, 2000.

Box 5.1: Using Technology Curves to Determine Policy Requirements

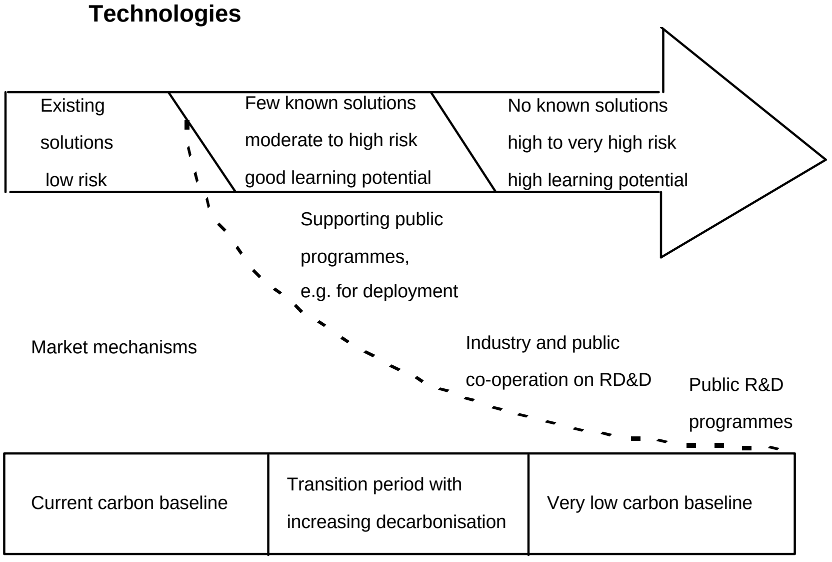


For photovoltaic systems to be competitive with currently used fossil fuel technologies, the cost of PV technology must be brought down to the fossil fuel alternative line in the diagram. The shaded area represents the amount of investment required in 'learning' to move the technology to breakeven (ie, the amount of investment required to make the technology cost effective). The time of breakeven depends on deployment rates, which can be influenced through public policies.

Source: Adapted from International Energy Agency, Experience Curves for Energy Technology Policy, OECD/IEA, 2000.

Figure 5.4 depicts how different policies are required to develop different energy technologies in response to different carbon baselines.

Figure 5.4: Roadmap for Policies on Decarbonisation Energy Technologies



Source: International Energy Agency, *Experience Curves for Energy Technology Policy*, OECD/IEA, 2000.

Moving from left to right, the top arrow indicates the types of technologies required to move the economy toward more sustainable energy production systems. The arrow moves from existing technologies with low market risk (mature technologies) through to those with very high risk and very high learning potential. These technologies relate to the scenarios provided in the bar below. For example, existing technological solutions with low commercial risk are appropriate to remain on the present baseline (ie, the business as usual case). However, if there is a desire to implement technology that stabilises around a new lower carbon baseline, then high risk and high learning potential technologies are required (radical technologies).

A variety of policies are appropriate for these different scenarios. For the business as usual case, market mechanisms determine the commercial technologies for use. For these technologies, development and deployment are internal industrial transactions determined by market mechanisms. Technologies considered in this category are advanced along the experience curve and have low learning rates and include coal and nuclear power technologies.

For the second scenario, where there is an increased focus on decarbonisation, public support is required in technology deployment and some R&D to move technologies further along their learning curves toward commercialisation. Technologies in this category include wind power, biomass and PV cells. Often deployment strategies are provided through support for niche markets. A risk of not providing deployment support is that a technology will not enter the market because it is too expensive and then will be denied the learning investment necessary to overcome the cost barrier.

For the third category of technologies, which focus on a very low carbon baseline, public R&D is required. Technologies in this category include artificial photosynthesis and high temperature superconductors.

Thus, to facilitate commercialisation of new technology, policy makers can focus on one or a combination of:

- altering the break even price, for example, by introducing carbon taxes;
- investing in RD&D; or
- implementing deployment strategies depending upon their objective.

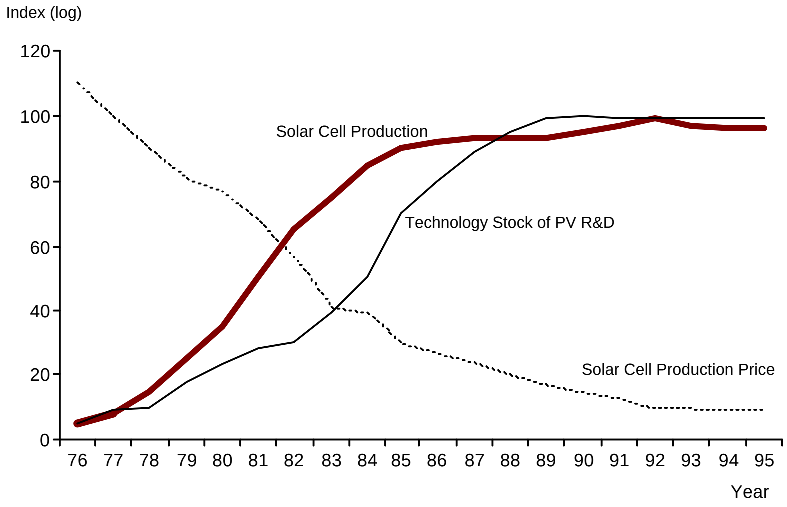
Box 5.2 provides an example of a policy program implemented in Japan aimed at increasing the development of photovoltaic power generation, which incorporates both RD&D and deployment programs.

Box 5.2: The Role of Experience Curves in the Development of Photovoltaic Power (PV) Generation in Japan

Japan has taken a leading role in the development of photovoltaic power (PV) generation technology. In 1974, Japan's Ministry of International Trade and Industry initiated a PV development program that aimed to maximise the benefits of learning effects, economies of scale and the benefits of technology spill over. The program:

- encouraged the broad involvement of cross sectoral industry;
- stimulated inter-technology stimulation and cross-sectoral technology spill over; and
- induced vigorous industry investment in PV R&D.

As a result of the program, the technology stock of PV R&D increased dramatically, in turn contributing to a significant increase in solar cell production. This led to a dramatic decrease in the cost of solar cell production, which heightened demand, and again induced further increases in solar cell production. The increase in solar cell production induced further PV R&D and created a "virtuous cycle" between R&D, market growth and price reduction. The figure below illustrates these trends in Japanese industry's technology knowledge stock of PV R&D.



The solar cell production price in 1974 was 20,000 yen/w and fell to 5000 yen/w in 1980, 2000 yen/w in 1983, 1200 yen/w in 1985 to 600 yen/w in 1994. The significant decrease in the cost of production is seen to be a function of inducement by technology knowledge stock and prices of energy combined with the impacts of learning effects and economies of scale.

Source: Chihiro, W, "*Industrial Dynamism and the Creation of a "Virtuous Cycle" between R&D, Market Growth and Price Reduction: The Case of Photovoltaic Power (PV) Generation Development in Japan*", IEA International Workshop on Experience Curves for Policy Making – The case of Energy Technologies, Stuttgart Germany, 10–11 May 1999 at http://www.me.titech.ac.jp/~iiasatit/9911-01.pdf

5.4 Conclusion

SEI technology is expected to increase its price competitiveness as renewable energy markets grow in scale and as experience grows. Experience is the single most important ingredient in achieving efficiency gains. This recipe has been proved in conventional business R&D again and again. Recognition of this potentiality is driving the intervention of governments in many energy markets overseas. High levels of government support —

both financially and regulatory — have assisted the industry to secure long-term investment and employment opportunities, and develop an export positioning.

In Australia MRET and other assistance measures were established with the intention of providing industry development support to the renewables sector and encourage learning in respect of the establishment and operation of renewable technologies. Learning of this sort brings costs down over time and, along with technical improvements relating to the efficiency of energy conversion, increases the overall competitiveness of renewable technologies. Such policies are important to help move the renewable energy sector down its learning curve in order to realise its economic and environmental potential.

6 Demand Management Drivers

The purpose of this chapter is to review a range of approaches to demand management and explore the capacity of selected DM measures if applied in urban and regional NSW centres. Beginning with a definition of DM and an analysis of its costs and benefits, there is a review of a number of the challenging barriers to DM implementation.

DM has the potential to drive material efficiencies in the NSW economy. Large companies applying energy efficiency in NSW are already achieving attractive rates of return, and network level initiatives could also replace capital expenditure at a time when generation and network constraints are becoming increasingly apparent. Aggressive implementation of DM could deliver the efficiency dividend that enables households and business to reinvest energy savings, creating jobs in the process.

Employment in the energy efficiency sector currently accounts for 70 percent of the jobs created in the sustainable energy industry. Thus, the DM industry (manufacturing, transport, installation, maintenance) would offer strong job potential if stimulated.

6.1 Definition of Demand Management

While definitions of demand management (DM) vary, the term is used here to encompass measures that smooth demand during electricity system peaks, as well as measures that improve energy efficiency generally (not just during system peaks). DM can provide environmental and economic benefits to the electricity generation, distribution and retail industries, energy end-users and the whole community. DM offers communities cost effective energy supply and end-use options, while driving investment in local industry and businesses and delivering more sustainable, regional energy management. The focus of DM is to meet customer needs through demand-related initiatives as opposed to increases in supply capacity.[30]

Traditionally, growing energy needs have been met by “build and generate” options, or expanding existing supply. This is both costly and greenhouse gas intensive. Through demand side management it is possible to meet energy needs at a lower cost while at the same time reducing environmental impacts.

6.2 Benefits of Demand Management

Currently, 10 percent of network capacity is required for less than 1 percent of the year. That is, 10 percent of expenditure on generation and network capacity (worth billions of dollars) is required to meet the highest system peak in energy demand for 1 percent of the year. This is unlikely to be an optimal use of infrastructure and economic resources.

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30 For a broad discussion of DM, see IPART’s *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, Interim Report, April 2002.

The Independent Pricing and Regulatory Tribunal (IPART) believe that this situation is worsening.[31] IPART has expressed serious concern about the potential for substantial increases in capital expenditure and worsening asset utilisation, with adverse consequences for costs faced by end-users.

The NSW Ministry of Energy and Utilities has identified the need to invest in substantial new generation capacity over the next ten years (up to 25 percent more capacity than is currently installed).[32] Substantial investment in transmission and network capacity worth billions of dollars is also foreshadowed. At the same time, IPART concludes that there is significant untapped potential for efficient demand management.

The costs and benefits of DM activities vary depending on the objective of the activity, for example, improving network performance and asset utilisation, managing retail exposure to price peaks, promoting customer energy efficiency to lower energy costs and reducing environmental impacts.

The varying objectives and nature of DM activities need to be kept in mind when considering costs and benefits. For example, a measure designed to promote overall energy efficiency (rather than reduce peak energy demand) will have potentially significant benefits for the end user in terms of lower year-round energy costs. Such measures will also result in lower emissions of GHG and other pollutants (by using less energy for the same level of output). Promoting energy efficiency can also benefit end-users by promoting greater ‘throughput efficiency’: meaning that fewer resources are needed to create the same level of output, and less waste is produced. Improved energy efficiency can also have an impact on peak energy demand by lowering the overall load curve.

However, general energy efficiency measures may not be the most cost–effective way to reduce energy demand during system peaks. This is because efficiency measures are not usually targeted for this purpose: their effect is spread across the whole load curve, rather than focussing on peak demand. This distinction should be kept in mind when assessing costs and benefits of various DM options.

Key potential benefits from DM are:

- reduced peak demand and better utilisation of generation, transmission and distribution infrastructure;
- deferral or avoidance of capital investments in network augmentation (generation, transmission and distribution) that would otherwise be required to meet system peaks;
- lower energy bills for customers;
- economic efficiency gains across the whole economy: less money is spent on energy infrastructure and this is released into the economy, growing jobs generally;
- embedded generation and improved efficiency can provide employment opportunities at the local and regional level, and keep more money in the region (due to savings on energy costs);

31 IPART, *Final Report*, October 2002, p.i.

32 NSW Ministry of Energy and Utilities, *Statement of System Opportunities*, 2002: www.energy.nsw.gov.au

- better quality and reliability of supply;
- more diverse and therefore secure supply (especially given increasing concerns internationally about security of supply);
- lower GHG emissions and therefore reduced exposure to future carbon costs; and
- environmental co-benefits: reduced emissions of other pollutants (eg SOx and NOx), improved regional air quality, reduced impacts on land use and improved water quality (eg from mining).

6.3 Demand Management Costs

To deliver benefits on a competitive basis, DM must compete on a ‘lowest cost available’ basis. As one important benchmark, the costs of providing energy services to end-users must be equal to or lower than traditional supply-side alternatives.

However IPART has recognised that current pricing structures do not accurately reflect the true cost of meeting peak demand. This affects the assessment of what constitutes cost-effective demand management (since non-cost-reflective electricity prices will often appear cheaper than undertaking measures to reduce demand). IPART notes that cost reflective price signals (eg, during system peaks) are not conveyed to half the market (residential and small business users). This distortion means that residential and small business users do not currently have the incentive to undertake demand side measures to reduce peak demand. IPART concludes that ‘better pricing is critical’ if DM potential is to be realised, along with its associated economic and environmental benefits.

The viability of each DM technology on a cost basis depends on the particular circumstances involved in its application. For example:

- for most DM initiatives, the average cost of available alternatives is the benchmark; but
- for standby generation (where other available non-grid sources are used during peak hours), the appropriate hurdle is the cost of energy during pool price peaks, which is much higher than the average cost; and
- in situations where there is a network constraint requiring capital expenditure, comparable network costs rise considerably (to $200/kVA), making even relatively expensive DM technologies quite commercially feasible.[33]

The figure below illustrates the indicative costs of facilitating a range of DM options. As can be seen, many of the options are more cost effective than spending $200 per additional kVA of network capacity.

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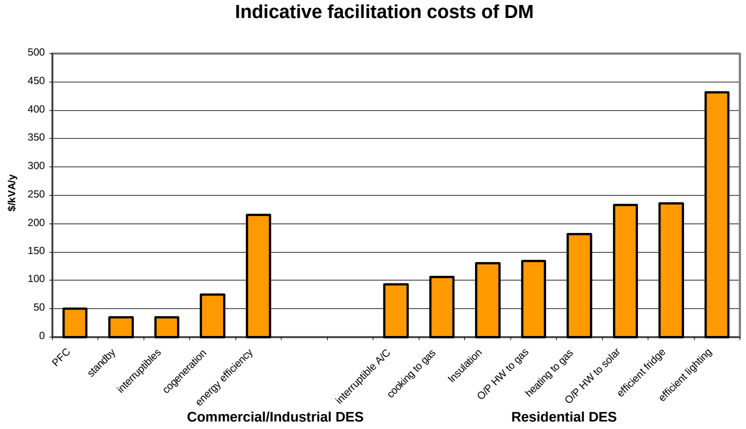
33 IPART, *Final Report ¾ Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, October 2002, p21.

Figure 6.1: Indicative Facilitation Costs of DM



Source: SEDA, *Demand Side Management: Evaluating Market Potential in NSW,* July 2001.

The costs indicated above relate to the cost of using such measures to *clip peak demand*. This is why, for example, efficient lighting appears to be an expensive option, that is, because improving efficiency across the board will be less effective in terms of smoothing peak demand than, for example, interrupting supply to a large commercial customer. However, efficient lighting etc can deliver substantial year-round energy cost savings to end-users.

Ultimately, the net present value of a DM technology's costs must be compared to the present value of capacity reduction provided to determine economic viability. Additional benefits such as GHG reductions should also be included in the test.

6.4 The SEDA Technology Compendium

To assist IPART in its investigation of DM alternatives in NSW, SEDA studied 35 distributed energy technologies to determine costs, capacities, and GHG reduction potential.[34] Twenty-one of these technologies were considered to pass the “low cost” threshold, and the 35 technologies had a collective capacity of around 5,900 MW of potential.[35,36] That compares to a NSW installed generation capacity of 12,270 MW, and a maximum peak demand of 11,900 MW. (Note, the Ministry of Energy and Utilities have identified the need for up to 3,000 MW of additional capacity over the next ten years.)

California’s “Cash for Kilowatts” is a US$20 million program aimed at providing incentives to commercial building owners and operators to reduce peak demand load. Suggestions for options are provided along with metering, feedback software. Small to large commercial buildings are eligible, and a quick response is required for turning appliances on or off when a signal is received from system operators.

The large SEDA DM potential capacity figure must nevertheless be tempered. Some technologies were not considered to be commercially feasible; others were not available in the short term; and still others could not be used to alleviate peak usage nor operate continuously. Still, the capacity for significant DM in NSW is considerable.

SEDA’s compendium of 35 technologies[37] covers a broad range of areas (see Appendix K). The consultancy team for this study reviewed the compendium and found that the mix of technologies identified as well as the costings and capacities associated with these technologies appeared to be broadly reasonable. While specific approaches set out in the compendium are reasonable, it is noted that it would be challenging to implement them all at once. It is worthwhile to heed IPART’s words of caution in relation to reducing barriers. IPART concludes:

> “The Tribunal believes it is important to assess the various barriers critically and to focus on the transaction costs and issues surrounding contracting for DM. It is also important to realistically assess the costs, and potential failure, of policies responding to these barriers. Although these concerns may lead to a more cautious incremental approach, the potential gains should not be underestimated. A recent study for FERC [US Federal Energy Regulatory Commission] estimated that better incorporation in market designs of demand-side responses to peak prices could reduce energy production costs in the US by $60 billion, or 5.6 percent of total production costs.”[38]

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34 SEDA, *Distributed Energy Solutions*, February 2002.

35 IPART, *Interim Report ¾ Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, April 2002.

36 Note that this capacity is not strictly additive as some options target the same or related loads.

37 For a full list of technologies reviewed, see http://www.seda.nsw.gov.au/pdf/DESpercent20Compendium.pdf

38 IPART, *Final Report ¾ Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, October 2002, p.28.

6.5 Barriers to Demand Management Take-up

For this Report, six demand side measures were included in the third modelling scenario described in more detail in Chapter 8. The measures comprise commercial and industrial energy efficiency, standby generation, interruptible contracts, natural gas cooling, residential energy efficiency and conversion of residential hot water to gas. Together, they represent a reduction in electricity demand of 1070 MW in NSW.

What prevents the total of 1070 MW DM capacity being realised? Why haven't these technologies been fully, or even materially implemented? IPART's review of DM identified six barriers to DM implementation:

- full costs not included in conventional energy prices (eg, GHG costs are not factored in);
- weak price signals (eg, half hourly metering would allow for charges and incentives for load management; and better profiles enable improved understanding of cost consumption patterns);
- imperfect information (eg, energy saving options, suppliers, advice would reduce transaction costs of switching to DM);
- risk and transaction costs (eg, there are many uncertainties about technologies, customer acquisition, evaluation, and payments, and information is rarely shared to reduce these risks and costs); and
- end-user preferences for simplicity and comfort (eg, cost is not the only factor considered by users, and perfect information might not convert a user — education is a long term behaviour-changing agent).[39]

There are responsive measures to address each of the barriers identified. In fact, SEDA's residential and business DM programs go to the heart of many issues raised and the NSW Government's mandatory greenhouse benchmark proposal is another example of addressing the cost of environmental externalities. But challenges remain.

6.6 Case Studies of Demand Management Excellence

This sub-section sets out case studies that show how these types of measures have been successfully implemented here and overseas. Some relate to peak clipping while others promote energy efficiency across the load curve.

There are ample successful examples of DM programs that reduce peak loads by interrupting supply. Some provide participating customers with more options in terms of how they value electricity during system peaks. In some programs, customers are able to easily exchange energy savings for energy efficiency items that increase household comfort, such as insulation. The following case studies provide good examples of successful overseas programs in the areas that we have modelled.

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[39] IPART, *Interim Report ¾ Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, April 2002, p. 13.

6.6.1 Sacramento Municipal Utility District Residential Peak Corps

More than a decade before the Sacramento Municipal Utility District (SMUD) prematurely retired its Rancho Seco Nuclear Plant, ushering in a dynamic period of demand-side management, SMUD implemented its Residential Peak Corps program as a full-scale initiative. The program then, just as it is now, was intended to address Sacramento's needle peaks that occur on summer days when temperatures climb above 100° F, sometimes for several days in a row.

The Residential Peak Corps program provides peak clipping/load shifting through the remote cycling of central air conditioners. SMUD typically cycles participating central air conditioners 10 to 16 days per summer with typical cycling durations of up to four hours. The program currently offers three cycling options with participants receiving discounts on their summer electric bills. Participants selecting the "Peak Performer" option may have their air conditioning curtailed for up to four hours in order to save up to $20 per month. Others who agree to curtail their air conditioners for 40 minutes out of the hour select the "Saver Plus" or "67percent option" and earn up to $15 per month in savings. For the "Basic Saver" or "50percent option", air conditioners are cycled for 30 minutes out of the hour.

While SMUD uses direct mail, local radio, and print advertising effectively, program participation has been enhanced greatly by SMUD's Rule 15, a requirement that all new homes with central air conditioners receiving power from SMUD must participate in the Peak Corps program. While homeowners may elect to subsequently disconnect, 78 percent of Rule 15 participants have remained in the program.

Customer satisfaction has also been a cornerstone of the Peak Corps program. To ensure satisfaction, SMUD provides customers the option of calling the utility and changing their cycling option or even dropping out of the program with as little as 24 hours notice. For participants, SMUD staff believe that communication is the key, not only educating customers about the program’s intent and operations, but also by providing customers with adequate advance warnings of power interruptions. Thus SMUD routinely runs announcements on local radio and maintains a hot-line for customer call-ins and information.

Residential Peak Corps is one of SMUD's most successful DSM programs. In fact, the program currently serves nearly 100,000 customers, an impressive 45 percent of eligible customers, and provides control of nearly 100 MW of peak demand at a current annual cost of about $3 million, or less than $250 per shifted kilowatt.[40]

6.6.2 Mirvac Group’s Partnership in SEDA’s Energy Smart Business Program

Since 1988, the Mirvac Group has been a partner in the SEDA ESB program. The group has the dual objective of reducing annual outgoings, resulting in savings for its major stakeholders, as well as reducing energy consumption and greenhouse gas emissions.

Mirvac has a diversified property investment portfolio that includes commercial offices, retail, industrial premises, car parks, and hotels. The cost saving motive has been a top motivator for Mirvac’s participation in SEDA’s ESB, because energy costs are a significant part of overall expenses in the property management industry. Some of

[40] http://www.iclei.org/cases/irt83.htm

Mirvac's largest buildings are covered by a memorandum of understanding it has signed with SEDA, including:

- the Optus Tower;
- Westpac Plaza;
- the Marriott Hotel; and
- Northmead Industrial.

Mirvac is also keen to ensure that the service delivery to its tenants should not be compromised by energy saving activities. Mirvac's mission statement emphasises "Leading Quality Brand", and energy consumption is considered a key driver towards achieving the goals underpinning its mission.

The Group has succeeded following the "learning by doing" paradigm. After successfully retrofitting the Optus Centre to achieve good energy savings results, they applied lessons learned to the Marriot Hotel, then other major properties. Applications centred on optimising chilling, air conditioning, lighting, water, and cooling fans.

Through its own energy efficiency practices, Mirvac has influenced the market for external consultants and contractors.

Mirvac's success in transforming its culture around energy efficiencies is linked to its ability to share information, make decisions, and communicate directions across various sections of the organization. The Group has established an Environmental Sustainable Management Committee that engages all divisions of Mirvac including its architects, development and investment managers.

Mirvac's results are impressive, and are growing.

- *Greenhouse emission reductions* — Tonnes of GHG saved range from 1,561 in the Optus Centre alone, to 611 tonnes in Mirvac's 40 Miller Street building in North Sydney. Total annual greenhouse savings are 7,866 tonnes.
- *Increased Occupancy* — Tenants are more likely to lease commercial office space in energy efficient buildings — Mirvac's occupancy rate is currently 97.5 percent.
- *Reduced Complaints* — Energy efficiency means services run more efficiently, which (especially in relation to air conditioning) means complaints have been reduced and tenants are more comfortable.
- *Cost Savings* — Annual cost savings in excess of $600,000 have been achieved so far following an investment of $917,000, or an internal rate of return of 67 percent.

6.6.3 Utility Competition and Conservation Promotion (Wisconsin, USA)

In June 1988, the Wisconsin Public Service Commission (Wisconsin PSC) directed Madison Gas & Electric (MG&E) to participate in a competition to provide DSM services to its customers. The winner would be the firm who achieved the greatest customer energy savings and be rewarded with a bonus of at least 10 percent of costs.

The following firms were selected competitors in defined sectors and allocated working capital:

- large commercial and industrial sector: Honeywell Inc.; allocated $348,500;
- commercial and apartment sector: A&C Consultants Inc., of Atlanta; allocated $392,500; and
- rental sector: Building Resources Management Corporation, a subsidiary of Puget Sound Power and Light in Bellevue, Washington; allocated $209,000.

MG&E was allocated a similar total and was allowed to compete in all three sectors as it saw fit.

Each competitor entered into a contract with MG&E to provide conservation services, for example, more efficient lighting or energy consulting services, using the funds allotted to them to meet the costs incurred. The final score was based on a combination of the quantity and cost-effectiveness of conservation benefits achieved, as determined from customer's electric bills.

According to Wisconsin PSC the competition was an "unqualified success". Total conservation value attributed to the competition was $13.6 million. Overall, conservation was worth 6.5 times cost. MG&E won both the Small Commercial & Industrial, and the Multi-family Rental industry awards and was awarded $200,000 for its performance. Honeywell won the Large Commercial & Industrial sector award and received a bonus of $40,000.[41]

6.6.4 Utility Incentives and Consumer Energy Conservation (California, USA)

In order to ensure the demand for energy services is met in the most cost effective manner, thirty states in the US have developed a system known as integrated resource planning (IRP).[42] Under IRP, states must calculate the costs, benefits and risks, associated with all practical generation and energy-saving techniques available. As a result of this policy, investments toward reducing consumption increased threefold within four years; from under $900 million in 1989 to approximately $2.8 billion in 1993. Under regulated markets, buying back energy through conservation can be significantly cheaper than generating it.

SMUD engaged in two programs of this type, the first being a refrigerator trade-in program to encourage the use of more efficient refrigerators where customers were offered between $100 and $175 to trade up to new, efficient models. Over thirty-seven thousand old refrigerators were exchanged and rebates issued for the purchase of forty-seven thousand new refrigerators. The second program offered homeowners a $850 rebate and 8.5 percent financing if they chose to replace an electric water heater with a solar water heater. Twenty-nine thousand SMUD customers chose to have the solar water heater installed. In 1995, it was estimated that SMUD would spend 7.2 percent of

41 Source: www.colby.edu

42 Market deregulation and industry disaggregation have, in the last five years, eroded the capacity for utilities in the US to undertake IRP. To ensure that restructured electricity markets continue to provide economically efficient DM, other mechanisms have been created such as Public Benefits Charges (see further in Chapter 9).

revenues on energy efficiency programs and loan $45 million to customers for energy saving improvements.

The cost of the refrigerator trade-in program, including state incentives, resulted in an average cost of four cents per kilowatt-hour saved while the cost to buy this energy from other sources would have been five to eight cents. Studies of other utilities found the cost of saving energy is generally even less than four cents per kilowatt-hour. In a survey of most DSM programs in the United States, it was found that the average cost of saving one kilowatt-hour was 2.1 cents. When saving electricity can be so much cheaper than producing it, it is clear why utilities now spend money to reduce demand. Incentives to electric utilities have become so large that over $2 billion is invested annually toward demand reductions.

Calculations showed that over the following twenty years, SMUD would be saving 800 MW of power with what was referred to as their ‘conservation power plant’. This is enough power for 640,000 customers. SMUD was turned into a model for utilities across the US. While in 1991 only 19 percent of energy in the US came from renewable sources, 54 percent of SMUD's power now comes from renewable sources.[43]

6.6.5 Shared Savings Incentives in Regulated Utilities (New England, USA)

In September 1989 the New England Electric System (NEES) submitted a plan to the regulatory authorities in Massachusetts, New Hampshire and Rhode Island proposing that NEES receive a portion of the “savings” resulting from demand side measures (DSM) it was prepared to institute. CEO John Rowe outlined an aggressive agenda by which NEES would spend $65 million, ±4percent of revenues, on DSM — effectively reducing the amount of electricity NEES could sell. The proposal, which had been developed in cooperation with the Conservation Law Foundation of New England (CLF), a Boston-based environmental advocacy group, was approved by mid-1990 by all three states with varied minor adjustments.

Shared-savings programs aim to break the link between profits and sales by rewarding the utility with a fixed portion of the estimated consumer surplus, calculated in terms of net present value, generated by using cost-effective demand-side measures to avoid costs. The reward structure is designed so that the utility has the opportunity to increase profits by earning a reward greater than the cost of lost sales. In the case of two of NEES's utilities this was achieved as follows:

1. *determine expected net benefit* — net consumer surplus, or net resource value, is equal to the total avoided supply costs minus the total cost of the DSM programs;

2. *recover DSM costs* — to reduce the risk of implementing DSM programs the total cost of the programs was to be recovered by the utility at the end of the year incurred;

3. *reward* — distribute a portion of the net benefit to the utility. Both Narragansett Electric (NE) and Granite State Electric (GSE) received 10 percent of the net resource value (to encourage cost-effective DSM) plus 5 percent of the total avoided cost (incentive to pursue all DSM opportunities, and not just "cream-skimming" those offering the greatest marginal net value). NE was allowed to earn the incentive on all savings beyond 50 percent of the goal net resource value. GSE earned the incentive on all savings, not just those exceeding 50 percent, once a threshold was exceeded; and

[43] Source: www.colby.edu

4. *lost revenues* — by definition DSM reduces growth of sales. For NEES the revenue lost through decreased sales volume was accounted for in the wholesale rates set by the Federal Energy Regulatory Commission (FERC), which allowed NEES a reasonable return on investment.

In this case the shared-savings program was profitable — NE and GSE earned an estimated 18 and 21 percent rate of return, respectively, on program costs. The total incentive return to NEES was approximately 12 percent of costs. Both NE and GSE generated a positive net resource value representing a cost avoided by society. This is an applied example of shared savings functioning as a positive incentive to DSM, decoupling profits from sales in a performance–based system that created benefits for ratepayers and utilities.[44]

6.6.6 Hawaii

Hawaii depends on imported petroleum for almost 90 percent of its energy needs and although Hawaii has no fossil fuels of its own — no oil, coal, or natural gas — it does have a wealth of renewable energy resources. These renewable energy resources include solar and wind energy, biomass, small–scale hydroelectricity, geothermal heat, and ocean thermal energy conversion. To reduce Hawaii's oil dependence, the state is actively supporting development of a mix of these energy resources along with DSM.

The following DSM Programs are in place in Hawaii:

- in 1993, the five Hawaii regulated utilities were required to file Integrated Resource Plans that cover the next 20 years. DSM programs are an important element of all of the plans. For example, Hawaiian Electric Company (HECO) anticipates a cumulative system peak impact of 194.5 megawatts in savings from DSM programs by the year 2010. Citizens Electric Company, Kauai Electric Division (KE), has proposed a plan to reduce peak loads by nearly 10 megawatts and reduce the need for a new generating unit by one year;

- HECO, Hawaii Electric Light Company and Maui Electric Company have already implemented a $2.5 million commercial lighting DSM pilot program, while KE completed a $105,000 residential pilot lighting program. Other pilot programs are being proposed by the utilities outside of the DSM programs included in their Integrated Resource Plans;

- GASCO Inc. is planning DSM projects to reduce energy consumption in the areas it serves;

- in addition, GASCO, Inc., HECO and DBEDT have on-going energy conservation/ efficiency education programs that supplement the state Department of Education's energy education curriculum;

- the federal Institutional Conservation Program is a retrofit program which in the past 11 years has stimulated over $12 million in federal, state, and private funds to install energy efficient lighting, air conditioning, and water heating systems in more than 170 public and private schools, universities, and hospitals. Expected savings are about $30 million over the life of the equipment;

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44 Source: www.colby.edu

- DBEDT also provides advice on energy efficiency to the Housing Finance and Development Corporation for its housing projects being built on Oahu and the Neighbour Islands; and

- county governments on Hawaii, Kauai and Oahu have replaced incandescent and mercury vapour streetlights with energy-efficient lighting. The federally funded Weatherisation Assistance Program, supplemented by other funds, has helped low-income families install insulation jackets and timers on water heaters, provided new heat pump water heaters, and offered advice on improving energy efficiency.[45]

6.6.7 Costa Rica Load Management Program

Over the past two decades the electric power sector of Costa Rica has performed satisfactorily, posting positive operating income and a reasonable rate of return. At the same time, it executed an ambitious investment program that increased the electricity service coverage of the population from 35 percent in 1971 to 90 percent in 1989. Between 1971 and 1988, total electricity sales increased on average 7.5 percent annually. In the 1990s electricity sales were forecasted to grow 5.9 percent annually. Despite these successes the sector has had some difficulty meeting its debt service obligations and its investment requirements.

By 1988, Costa Rica's utility, Instituto Costarricense de Electricidad (ICE), was concerned that peak load growth would eventually eat into capacity reserves resulting in possible shortfalls in capacity. Two peaks marked ICE’s load curve for a typical day: the morning peak occurring between 10:00 am and 12:30 pm and the slightly higher evening peak occurring between approximately 5:00 and 8:00 pm. The major contributor to the two peaks is the substantial use of electricity for cooking in households.

These peaks led to a load factor of around 59-60 percent. Most of the load management and control strategies addressed in this project focussed on options targeted to large commercial and industrial (C&I) customers with monthly consumption levels of at least 20,000 kWh or a maximum demand exceeding 100 kW.

The project's final objective was to demonstrate that the aggregate coincidental peak demand of a representative sample of industrial and commercial enterprise could be reduced by 10 percent at a cost acceptable to both electricity users and the utility.

The project design estimated that a 1.0 kW reduction in customer peak demand would result in approximately 1.4 kW reductions in generation capacity, assuming a 30 percent dry year planning reserve margin, and 10 percent loss factor on-peak. This implies that a 1.0 kW reduction in peak load through a load management program could save $781.20 in generation capacity alone. Using an annual capital recovery factor of 0.2, this would translate into a savings of $156.24/kW-year, or $13.02/kW-month. In addition, savings would accrue annually because of reduced fuel (diesel), oil and furnace oil-requirements during peak periods. Furthermore, savings in capital expenditures would accrue because of reduced/delayed expenditures for transmission and distribution.

ICE carried out this pilot project with technical assistance from USAID. RCG/Hagler Bailly carried out the project in 1988 under contract to USAID and by FPL Qualtec, a subsidiary of Florida Power & Light.[46]

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45 Source: http://www.hawaii.gov/dbedt/ert/dsm_hi.html#anchor345946

46 http://www.weea.org/best/CostaRica/01.htm

6.6.8 US EPA's 'Golden Carrot' Super-Efficiency Program

By channelling the natural competitiveness of the marketplace, government challenges can also bring about important environmental advances in products. Under the 'Golden Carrot' Super-Efficiency Program in the US, network service providers subsidised manufacturers to deliver and/or develop new high-efficiency equipment, including refrigerators, industrial air compressors, pumps, fans and drives and other industrial process technology to make them the same price as less efficient models. Customers bought the efficient models because the purchase price was the same while the operating cost was much lower.

Providing incentives to purchasers in this way changed the market place and as a result manufacturing practices. The cumulative energy efficiency savings were so great that the need for capital-intensive electricity network augmentation was substantially reduced.[47]

6.6.9 Integral Energy

Integral Energy has initiated 'curtailable load' activities with industrial customers in the Liverpool, Seven Hills and Wetherill Park/Bossley Park Zone substations. These projects have been estimated to provide a net present value of some $19 million in deferred capital expenditure.

There is also strong potential to undertake DM in the residential sector. In the summer of 2000-01, Integral Energy with support from SEDA undertook an interruptible air-conditioning project designed to control residential customers' air-conditioners. Using remotely operated control equipment, Integral was able to turn off air-conditioners for brief periods during peak demand. The study determined that the control equipment performed as required and that, in general, there was a positive customer reaction to the program. Switching off air-conditioners reduced household energy demand significantly.

Such measures will become increasingly cost effective as the NSW energy system shifts from a winter peak to a summer peak (in response to increasing use of air conditioning in the residential and commercial sector). There is also strong potential to improve the efficiency of air conditioning in the commercial sector — see the section on the Australian Building Greenhouse Rating Scheme in Chapter 7.

6.7 Conclusion

IPART concludes that demand management, broadly defined, will be critical to how the energy sector meets the challenges of:

- investing potentially large amounts of capital in generation and network assets to meet growing, and increasingly peaky, demand for energy;
- volatile and rising prices as the demand-supply balance tightens;
- increasing competition from smaller-scale, more flexible technologies; and
- reducing greenhouse gas emissions and other environmental externalities.[48]

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47 http://www.epa.gov

IPART stated that, "Potentially massive increases in network expenditure to meet demand growth highlight the importance of getting demand management right."[49]

The case studies outlined above show that significant demand side savings can be realised with appropriate settings and drivers in place. Recognising the economy-wide benefits of DM, governments around the world have implemented measures in support of DM, including incentives and funding support. The IEA's Alternative Policy Scenario also highlights the importance of demand side measures in responding to climate change — for further detail see Chapter Two.

It is clear that a key policy challenge for governments in Australia is to overcome barriers to demand management in order to realise potentially significant economic and environmental gains and to keep pace with increasing efficiency across the OECD.

The NSW Greenhouse Benchmarks scheme provides scope for retailers and large energy users to reduce greenhouse gas emissions through energy efficiency measures. This is an important step towards encouraging DM. However, as IPART suggests, further work is likely to be required to overcome barriers to DM (eg, non-cost-reflective pricing) in order to realise its potential more fully.

As detailed in chapter eight, the modelling undertaken for this Report supports the conclusion that DM is worth getting right. In addition to its potentially significant environmental benefits, DM can deliver strong economic benefits and jobs growth, not only in the sustainable energy industry but also across the whole economy.

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48 IPART, *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services: Final Report*, October 2002, foreword.

49 IPART, *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services: Final Report*, October 2002, foreword.

7 Sustainable Energy Technologies ¾ Case Studies

At SEDA's request, The Allen Consulting Group has reviewed in detail seven selected sustainable energy technologies from their Distributed Energy Solutions Compendium (the "Compendium"). The review is provided as an illustration of the possible paths to competitiveness for the SEI. A contemporary understanding of how various technologies are performing creates a platform for determining how and where to drive NSW policy changes in order to achieve leadership in the SEI sector. Competitiveness in attractive technologies and in the application of those technologies will act as a magnet for investment and will create energy sector job opportunities.

In reviewing the Compendium, the range of technologies covered was considered with a view to expanding them if appropriate. Against this background, it was considered that biodiesel should be included as one of the seven technologies considered even though it is not covered in the Compendium. A key factor was the link between biodiesel and one of the peak clipping demand management measures ¾ standby generation ¾ included in the Compendium and modelled in the Demand Management Scenario discussed in Chapter Eight. The standby generation measure involves reducing peak demand by using standby diesel generators found in many commercial and industrial buildings. However, running hundreds of diesel generators in the basements of CBD buildings also raises environmental questions. If biodiesel was used to run these generators, the overall environmental outcomes could be improved.

7.1 Introduction

This report outlines seven sustainable energy technologies selected from the Compendium. Each technology described includes:

- an overview description of the technology itself;
- a description of the way in which greenhouse gas emissions are reduced by the technology;
- an overview of the local and international market for the technology; and
- the details of Australian and international policies associated with the technology.

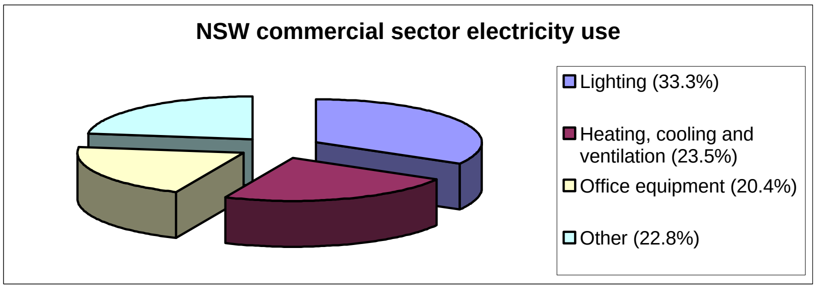
Several criteria were used to select the relevant technologies for this report. Firstly, all 35 technologies from the Compendium were ranked in relation to their ultimate total ability to reduce greenhouse emissions (to the value noted in the Compendium) plus the implementation, operation and production costs (based on total capital plus estimated associated network, capital and marginal generation costs as noted in the Compendium). After ranking the technologies, seven were selected, not only on the basis of their rank but other factors such as ensuring a mix of supply and demand side technologies and a mix of technologies relevant to a wide range of stakeholders (for example, photovoltaics ranked toward the bottom of the 35 technologies in the Compendium, however, it was included on the basis of broader considerations).

7.2 Commercial – Industrial Energy Efficiency

7.2.1 Technology Description.

The AGO, SEDA and others consider improved energy efficiency as one of the most cost effective methods of reducing greenhouse gas emissions. Two broad categories are targeted by the AGO: appliance & equipment and buildings. Within these categories are best practice programs aimed at increasing the use of high efficiency motors and drives and high efficiency lighting as well the development of minimum energy performance standards (MEPS). The AGO is currently developing MEPS for electric motors, fluorescent lamp ballast, commercial refrigeration and distribution transformers. Figure 7.1 shows a breakdown of commercial energy use in NSW.

Figure 7.1



Source: SEDA

SEDA provides information about energy efficiency to a wide range of companies and runs the Energy Smart Business program through which it works with larger companies to improve their energy efficiency. It also developed the (now national) Australian Building Greenhouse Rating Scheme, which helps commercial building owners and tenants to reduce energy costs and greenhouse emissions.

7.2.2 Greenhouse Gas Abatement

Greenhouse gas emissions from energy consumed by equipment and appliances are responsible for a quarter of net greenhouse emissions in Australia (excluding land use change and forestry).[50]

Typically, a 5 to 20 percent energy saving could be achieved by implementing energy efficiency programs. Greenhouse gas abatement from various programs is as follows:

- the MEPS program is expected to save 4 million tonnes of greenhouse gases over 15 years;[51]

50 The Australian Greenhouse office website, www.greenhouse.gov.au

51 Industry Science and Resources (ISR) website

- the 'Energy Star' program is expected to save $2.4 billion by 2015[52] (58.5 Mt of greenhouse gases);[53] and

- voluntary measures for energy savings in the commercial buildings sector are expected to save between 12 Mt to 20 Mt.[54]

7.2.3 Market Analysis

The market for energy efficient products is fragmented and overall figures are not available, however, the following gives an indication of its size.

The AGO estimates that there are more then 1.7 million three-phase electric motors in commercial and industrial facilities. This represents 28 percent of commercial and industrial electricity use or $3 billion per year and 37 million tonnes of carbon dioxide.[55] Fluorescent lighting represents 7 percent of national electricity usage and an estimated 84 percent is low efficiency.[56]

Australia has very limited manufacturing capacity in the area of lighting and imports the majority of its lights. There is potential to increase Australian capability in this area, for example in the production of triphosphor lamps.

Australia lags behind world best practice in energy efficiency and there is strong potential to improve efficiency in the commercial, industrial and residential sectors. The following list indicates the potential gains in the commercial and industrial sectors:

- upgrading lighting can save 40–80 percent of lighting energy costs;

- using energy-efficient office equipment can reduce energy consumption of individual products by over 50 percent;

- a Building Management System can cut total energy costs by up to 30 percent;

- proper use and maintenance can save 20-70 percent of heating ventilation and air conditioning operating costs;

- conserving hot water and using the appropriate hot water system can save 80 percent of water heating energy costs;

- energy cost savings of up to 40 percent can accrue by improving motor systems;

- reduce energy costs by over 80 percent by halving the speed of pumps or fans;

- industrial facilities can reduce steam energy consumption by 20 percent through simple improvements in their steam system; and

52 Industry Science and Resources (ISR) press release

53 Greenhouse gas estimate by GHD

54 AGO, *Australian Commercial Building Sector*.

55 ISR, *Greenhouse Gas Emissions 1990 – 2010.*

56 George Wilkenfeld and Associates, *Regulatory Impact Statement: Minimum Energy Performance Standards and Alternative Strategies for Fluorescent Lamp Ballast*.

- stopping air leaks can save 25-40 percent of energy costs.[57]

Streetlights

There is also strong potential to increase the efficiency of streetlights.

In November 2002, Coffs Harbour City Council in partnership with Country Energy and SEDA launched an energy efficient street lighting project, the first of its kind in NSW. The project will reduce greenhouse gas emissions and the operating costs of street lighting by upgrading inefficient and high maintenance street lamps.

After trials of a range of more energy efficient technology options in two residential areas, the development of a full financial model to assess the most cost effective options, a new Service Level Agreement and a new plan for the complete upgrade of Coffs Harbour City Council's street lighting has been agreed.

The new options will reduce energy consumption and greenhouse gas emissions by 20 percent, reducing emissions by 384 tonnes per annum. The Council will also save $58,000 a year in street lighting costs. The net present value of the savings of the project over the next 20 years is $658,382. If successful, the project will be used as a model for other councils across NSW.

Traffic Lights

There is also strong potential to increase the efficiency of traffic lights. Installing light emitting diode (LED)[58] traffic lights in connection with the construction of new roads and replacing existing incandescent lights can generate significant savings in terms of energy, greenhouse gas emissions and maintenance costs.

LEDs have a number of advantages over traditional incandescent globes:

- LEDs typically use up to 80 percent less electricity than incandescent globes;
- LEDs have a life of 10 years (versus 1-2 years for incandescent globes), thus reducing replacement and maintenance costs; and
- LEDs fail progressively rather than suddenly, which is safer for motorists and maintenance crews.

LED lights are a proven technology and are widely used elsewhere in the world, particularly in the USA, Singapore and Sweden where they have replaced incandescent globes in many regions. This has delivered huge savings in energy, CO_2 and other emissions (NOx, SOx which contribute to smog formation), and installation and maintenance costs. In some cases, LED programs were supported by rebates or other financial assistance from local utilities or other organisations. In other instances, energy savings were used to underwrite the costs of purchasing and installing the new fixtures.

57 SEDA, *Energy Savings Manual*, 2000.

58 Light emitting diodes are used in a number of applications including mobile phones, printers, computers and increasingly in signage applications.

Examples of overseas LED programs

Singapore

Traffic signals over the entire island of Singapore have been replaced with LED signals. There are 57,000 traffic signals at more than 1,500 intersections. The estimated cost-savings from replacing the prematurely fused light bulbs alone is estimated to be around $158,000 per annum.

Pennsylvania

In April 1997, the City of Philadelphia began a two-year, US$3 million replacement of approximately 28,000 signal heads with LEDs at all city intersections. In 1998, the project saved $270,000 in energy costs, with savings of $750,000 in 1999. During 2000, the first full year of citywide LED signal operations, the estimated annual energy savings was $887,000, plus additional savings of $165,000 from lower maintenance costs. Philadelphia estimates that the project will avoid almost 7,000 tons of carbon dioxide emissions annually, as well as 80 tons of sulphur dioxide and 25 tons of nitrogen oxides.

California

Approximately 30 Californian municipalities have installed LED traffic signals. The California Department of Transportation (Caltrans) installed up to 72,000 LED traffic signal fixtures in 1999 and 2000. This project saved the State and local governments an estimated 47.3 million kilowatt-hours of electricity. The energy savings will be used to underwrite the costs of purchasing and installing the new fixtures. Most of the municipalities in California that have used LEDs received some form of rebate or other financial assistance from local utilities or other organisations. Several of the communities that have not installed LEDs stated that the lack of funding was a barrier. However, many municipalities were willing to install LED signals without depending upon rebates to do so.

Australian Potential

To date there is no example of a large-scale introduction of LEDs in Australia. However, VIC Roads has trialed LEDs in a few intersections and has received approval to install LEDs in all new intersections. Victoria's annual energy bill for traffic lights is approximately $3 million and it has been estimated that there would be savings of $2.5 million per year and 40,000 tonnes of carbon dioxide if all traffic lights were changed to LEDs. Adelaide City Council is proposing to install LEDs with a view to cutting their annual traffic signal electricity bill from $194,000 to $34,000.

The NSW Roads & Traffic Authority has installed some LED pedestrian lights and traffic lights, which have now been in place for 2-3 years. An Australian Standard, including standards specifically for LED traffic lights, has now been released and there is strong potential to roll out LEDs on a wider scale in order to achieve strong efficiency gains and other benefits. It is estimated that the capital cost of installing LED signal heads in all new traffic light installations could be recovered quickly, with an internal rate of return of 30 percent.

7.2.4 Government Support Policies

The Federal Government's policy is to promote improvements in energy efficiency by extending and enhancing the effectiveness of the existing labelling and minimum energy performance standards (MEPS). The new standards are mandated by state regulations and set out in Australian Standard AS 1359.5:2000.

Through the AGO, the Energy Efficiency program also manages the ‘Energy Star’ program, building energy efficiency as well as lighting efficiency.

The AGO ‘Greenhouse Challenge Program’ is a voluntary agreement by signatories to reduce greenhouse gas emissions through reducing energy consumption.

The Commonwealth Government, through the Industry, Science and Resources Department, has a target to reduce energy consumption for Commonwealth operations by 25 percent compared to 1992-93 levels.[59]

The Commonwealth Government's Energy Efficiency Best Practice (EEBP) program is administered by the Federal Department of Industry, Tourism and Resources (DITR) which works cooperatively with other government agencies and industry associations to identify and implement cost-effective energy saving measures. The program focuses on innovation, training and benchmarking to achieve improved efficiency, lower costs, higher profits and reduced greenhouse gas emissions.

Through Big Energy Projects, which include innovation workshops, organisations are encouraged to look beyond daily operations to explore innovative, cutting-edge solutions, including accessing technologies and specialist expertise not previously used within their sector, to achieve significant ‘big step’ improvements in energy efficiency. The EEBP is a key component of the Commonwealth Government’s package of measures to address climate change, announced in November 1997. The program was allocated $10.3 million over five years to support development and implementation.

SEDA’s Energy Smart Business (ESB) Program assists NSW businesses to cut operating costs and reduce GHG emissions by undertaking energy efficiency projects. Funding is provided for energy efficiency experts to analyse individual firms’ operations and energy costs and identify energy and cost-saving initiatives. To date, 170 NSW companies have joined the program, achieving $19 million in annual energy savings and reducing greenhouse gas emissions by 315,000 tonnes C02-e every year. Energy Smart Business partners have invested more than $50 million in energy efficiency projects with an average rate of return on investment of 37 percent.

SEDA also works with government agencies to improve their energy efficiency and lower costs. The Energy Smart Government program utilises ‘Energy Performance Contracting’, whereby a partnership is developed between the agency and a contractor who will implement energy savings measures and guarantee the level of savings. The contractor is paid from the savings achieved. As a significant energy user, governments have strong potential to reduce energy use and emissions. Governments also have a role to play in leading by example: saving money and reducing emissions, while also helping to grow the sustainable energy industry by creating demand for sustainable energy technologies and know-how.

The NSW Environment Protection Authority’s (EPA) ‘Profiting from Cleaner Production Industry Partnership Program’ offers matched funding to help individual businesses, clusters of businesses and industry sectors introduce cleaner production processes. The NSW Government has funded the Program with $5 million over three years from the Waste Planning and Management Fund.

The NSW Government’s proposal to enforce mandatory greenhouse benchmarks makes provision for retailers and large users to reduce emissions through improved energy

59 ISR, *Energy Use in Commonwealth Operations 2000 – 2001.*

efficiency. The introduction of a penalty for non–compliance with the benchmarks could help provide incentives for energy efficiency measures. The Australian Building Greenhouse Rating Scheme (ABGRS) is a voluntary scheme that seeks to reduce the greenhouse impact of commercial office buildings and tenancies through benchmarking their greenhouse performance. Buildings and tenancies are rated on a scale of one to five with the more stars a building or tenancy receives, the better its greenhouse performance. A three star rating represents current best market practice with many buildings and tenancies currently rating at 1–2 stars. Star ratings can be improved through a range of measures such as installation of energy-efficient lighting/office equipment and purchase of Green Power.

Commercial buildings in Australia spend around $4 billion each year on energy and produce 8.8 percent of national GHG emissions. Emissions from this sector are growing by 3-4 percent per annum. Energy efficiency can provide cost effective financial savings, reduce emissions, contribute to improved productivity and provide marketing benefits.

There is very strong potential to increase the efficiency of commercial buildings. Efficiency gains in this sector, especially when targeted in a network-constrained area, can make an important contribution to managing peak energy demand, particularly given the shift in NSW towards a summer peak (as a result of increased use of air conditioning in the commercial and residential sectors). Promoting high efficiency air conditioning systems and managing their use can be an effective demand management tool.

The ABGRS is being used to rate groups of buildings in North Sydney and Parramatta, as well as other buildings across the country. Already, participants are achieving significant energy savings and GHG reductions. SEDA estimates that, if the 16 participants in the North Sydney trial increased their building star rating from 3 to 4 stars, energy cost savings would be over $4 million per annum with a reduction of more than 50,000 tonnes of CO_2 emissions.

Some commercial DM case studies are set out in Boxes 7.1 to 7.7.

Box 7.1: Energy Australia

Energy Australia halved the energy used by its head office through a range of strategies, including:

- improvements to the heating, ventilation and air conditioning (HVAC) system, such as the implementation of full fresh air cycle and heat recovery from the chiller;
- installation of energy-efficient lighting;
- power factor correction; and
- installation of a building management system.

These upgrades were implemented over a four-year period. Greenhouse gas emissions were reduced by more than 4,400 tonnes per year, raising the Building Greenhouse Rating from less than 1-star to 4-star.[60]

60 SEDA, *Building Greenhouse Rating.*

Box 7.2: Office of Energy Policy

The Office of Energy Policy, South Australia (now Energy SA) monitored the energy used by its central photocopier and found that most energy was consumed when the copier was on standby. A $40 timer was purchased, which turns the unit on between 8 am and 6 pm weekdays. Energy savings repaid the cost of the timer within three months. The timer chosen can be easily overridden if the copier is needed outside normal operating hours. Annual greenhouse gas savings are estimated at just over a tonne of CO_2 equivalent for one copier.[61]

Box 7.3: Adelaide City Council

Adelaide City Council has conducted a detailed and thorough investigation of energy use by its office equipment (especially computers, printers and photocopiers). Actual measurements of energy use of some computers before and after enabling *Energy Star* power saving features, and detailed calculations by the in-house energy manager found:

For 370 computers	CO_2 emissions (tonnes / year)	Annual energy cost ($ / year)
Before enabling Energy Star features	216.5	29,619
After enabling Energy Star features	107.383	14,694
Energy Star Savings	***109.117***	***14,925***

This analysis showed that savings of approximately $15,000 and 109 tonnes of CO_2 could be achieved without any additional capital expenditure.

In addition, the Council calculated that it could save a further $9,700 and 70 tonnes of CO_2 per year by enabling the Energy Star features of its other significant energy consumers such as its 45 photocopiers and 30 printers. Some of these savings have already been achieved. Older equipment (without Energy Star features) is likely to be controlled using supplementary inexpensive timers.

To ensure the full benefits are attained, the following measures have been implemented:

- the existing electronic office equipment purchasing policy has been amended to require compliance with current relevant energy star specifications; and
- Energy Star features on all new computers and other electronic hardware are being enabled at the time of initial installation and following repairs or regular maintenance.[62]

Box 7.4: Efficient Lighting

The following projects, which have been independently monitored, indicate the savings that have been achieved, with various lighting strategies applied to existing installations:

Strategy	**Savings**
Time Switching	
SECV, Melbourne (Office)	45 percent
Office of Energy, Adelaide (Office)	44 percent

61 Source: Energy SA

62 Cities for Climate Protection (CCP) Australia

Dept of Health, ACT (Office)	59 percent
NSW Dept of Education (Education)	60 percent
Occupancy Switching	
Telstra Exchange Melbourne	64 percent
Occupancy and Time Switching	
Telstra, Melbourne (Office)	45 percent
Adelaide TAFE (Education)	51 percent
Photoelectric Solar Controller and Time Switching	
Panorama TAFE (Education)	57 percent
Photoelectric Control	
Melbourne City Council (Industrial)	62 percent
Intelligent Light Fittings	
Energetics, Sydney (Office)	85 percent

Box 7.5: Fairfield Council: Lighting Upgrade

Fairfield City Council undertook a major lighting upgrade at their Nelson Street car park. The result is a lighting solution that has not only improved security and increased lighting levels between 200 and 600 percent in the car park, but is also a model of energy efficiency. The new energy efficient lighting will reduce energy consumption by 285GJ a year, cut co2 emissions by 73 tonnes — the equivalent of taking 16 cars off the road — and save Council $8,538 in energy bills a year. The car park now has increased lighting levels without any increase in power consumption. This has been achieved by using a more efficient light source, in particular, 114 175 watt metal halide lamps.

Box 7.6: Newcastle City Council

Newcastle City Council cut the energy used by its administration centre by improving the efficiency of its fluorescent lighting systems, including:

- introducing an intelligent light switching system, with local area control for timed switching after hours;
- installing low-loss ballasts;
- re-lamping with triphosphor fluorescent tubes;
- removing one lamp from three-lamp luminaires;
- installing automatic sensor controls on lighting systems in the building's toilets; and
- installing a centralised power factor correction system.

The total investment was $101,500. As well as significant ongoing savings ($67,000 every year, a 40 percent reduction in energy costs), the upgrade also resulted in improved lighting quality and lower maintenance costs. Greenhouse emissions were reduced by nearly 350 tonnes per year, raising the Building Greenhouse Rating from 1-star to 2-star.[63]

Box 77: Arnott's: Energy Smart Business Partner

Arnott's identified lighting and air conditioning as two areas where there were significant energy savings to be made at their plant in Huntingwood. In total, 20 energy efficiency projects have been initiated including improvements to oven efficiency, installation of occupancy detectors to light switches and a reduction in the number of office lamps by 30 percent. To date, Arnott's has achieved $227,139 in annual savings from an investment of $59,755.

63 SEDA, *Australian Building Greenhouse Rating Scheme*, see www.abgr.com.au.

7.3 Industry — Small Cogeneration

7.3.1 Technology Description

Small-scale gas fired cogeneration or combined heat and power (CHP) systems can be defined as the burning of gas in a system to generate electricity, a by-product of which is heat. This heat is then utilised for space heating, hot water generation, process heating and other processes such as cooling via an absorption chiller. By recovering and utilising the heat in this manner the overall thermal efficiency of burning the fuel can typically be increased from around 30 percent for a traditional centralised gas burning power station up to 85 percent for a small scale gas cogeneration system.

In traditional centralised large-scale power stations, this by-produced heat is usually discharged (wasted) to the atmosphere. The increase in thermal efficiency is a direct result of the heat produced by generating electricity being utilised for other processes.

7.3.2 Greenhouse Gas Abatement

Greenhouse gas abatement or reduction in CO_2-e is a direct derivative of cogeneration because, should the heat generated by a cogeneration plant have to be generated via a stand-alone heat generating plant (ie, a boiler), then the additional fuel burnt in the boiler would create CO_2-e. This is best illustrated in Figure 7.1.

Figure 7.1: Traditional Power Station and Boiler Plant

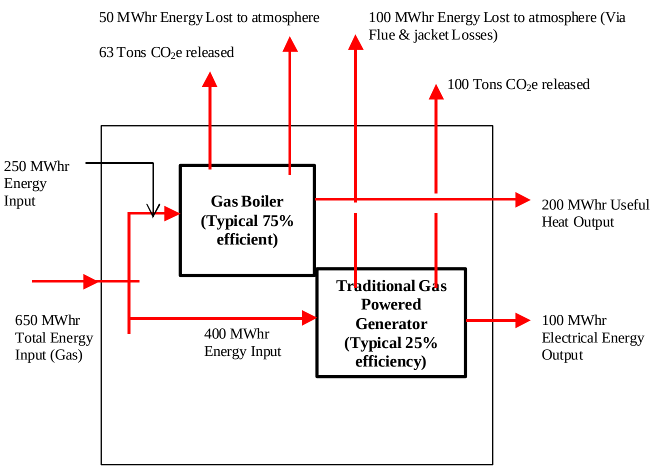
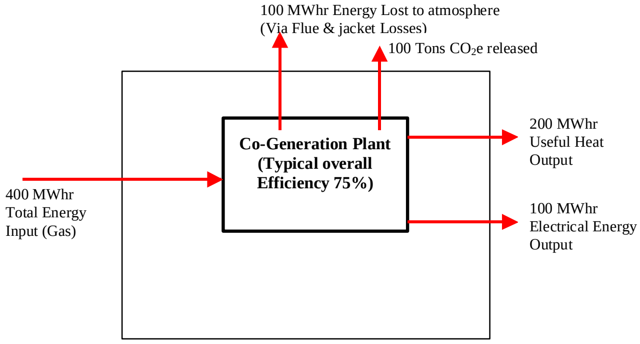


Figure 7.2: Cogeneration Plant



Source: GHD

Data comparing traditional power stations and boiler plants with a cogeneration plant are shown in Table 7.1.

Table 7.1: Comparison of Energy Inputs, Outputs and CO_2.e Emissions for Traditional and Cogeneration Plant (all gas fired)

	Energy Input MWh	*Electrical Energy Output (MWh)*	*Useful heat output (MWh)*	*Total CO_2e emissions (Tonne)*	*Total Energy Lost (MWh)*	*Overall Efficiency (percent)*
Traditional	650	100	200	163	350	46
Cogeneration	400	100	200	100	100	75

Source: GHD estimates.

The greenhouse gas abatement benefit for a given output of energy is clearly illustrated in Table 7.2. Also illustrated is the increased efficiency of the cogeneration system.

Although gas has been used for the comparison in this example, similar figures for CO2-emission are obtained if the traditional power stations were coal fired, although the overall efficiency would increase to approximately 54 percent and energy input reduced to 550 kWh (300 kWh coal, 250 kWh gas). This is due to the increased efficiency of burning coal (typically 33 percent for coal as opposed to 25 percent for gas). The CO2-e emission would arguably remain the same due to the increased CO2-e emission output from burning coal.[64]

Aside from lower GHG emissions, cogeneration also has several other benefits. Because cogeneration capacity is typically located in the distribution network, it avoids transmission losses (meaning lower GHG emissions per unit of delivered energy) and helps defer or avoid capital expenditure on augmentation of transmission and distribution capacity. As noted in Chapter 6, savings on network expenditure can be significant. Cogeneration also contributes to greater diversity and therefore security of supply (for the host site as well as the whole system), as well as providing high quality supply.

64 GHD estimates.

7.3.3 Market Analysis

General

In order for small-scale cogeneration to be successful it should be viewed primarily as a heat generating system, a by-product of which is the production of electricity. This electricity can then be utilised on site, stored in batteries for future on site use or sold back to the grid. Effectively meaning that "heat is the key" to a successful system.

As Australia's climate is one that predominately requires cooling, large scale cogeneration combined with district heating systems as found in many cooler European countries is not feasible. Furthermore, the large scale centralised sites where traditional power stations are located and where perhaps a large scale cogeneration plant could be incorporated in any upgrade/replacement works are generally located away from the populus, making the distribution of resultant heat an unrealistic prospect.

Therefore, it is arguable the way forward for cogeneration in Australia and the world as a whole is in small decentralised cogeneration plants where the power and heat required are located and matched to the source, with any shortfall or excess in power generated taken up by the grid. SEDA estimates that there is considerable potential to use small-scale cogeneration in place of existing boilers in the Greater Sydney region.

Current Australian Market

According to the Australian EcoGeneration Association[65] (AEA) cogeneration accounts for approximately 5 percent of the Australian power generation market with the potential to grow to 10 percent by 2010. The AEA has also undertaken a study into the amount of operational cogeneration projects operating in Australia as of 30 June 2001; their findings are summarised in Table 7.2.

Table 7.2: Cogeneration Capacity By Industry in Australia

	MW	No of Projects	Average MW/project
Alumina	652.5	7	90
Sugar	343.4	30	11
Paper	285.0	9	31
Nickel	261.0	6	43
Chemical	215.7	6	36
Oil refining	215.0	5	43
Misc manufacturing	214.6	4	53
Mineral processing	76.9	4	19
Steel	73.7	3	25
Health	60.0	24	2.5
Waste water	20.8	9	2.3
Food	13.4	10	1.4
Building	7.9	7	1.1
Education	7.6	3	2.5
Recreation	2.9	11	0.26
	2,455.4	139	

65 Sustainable Energy Innovation a New Era for Australia – CL Creations 2002

According to the table, the largest employers of cogeneration are the energy intensive industries such as alumina, sugar, paper, etc. This is due to the electrical and heating demands being evenly matched and being at a single point of use to make cogeneration an attractive prospect (see Box 7.8).

Box 7.8: Bulwer Island Cogeneration

The Bulwer Island cogeneration project, owned by Origin Energy and ATCO Power, was commissioned in September 2000 and comprises two 12 MW Alstom gas turbines and an 8MW steam turbine that produce a total of 32MW of power. Steam is recovered from the gas turbine waste exhaust gases and used to raise steam through a heat-recovery steam generator and then supplied to BP for use in its petroleum refinery. The cogeneration project is an integral part of a $500 million upgrade to the refinery that enables BP to reduce sulphur and remove lead from petrol.

The cogeneration project uses coal seam methane form the Bowen Basin that is supplied to the project by Origin Energy. Refinery gases from BP are also used on site in the auxiliary boiler. Power from the project is used to meet BP's on site requirements with excess power sold to Energex, the local electricity retailer. The plant uses recycled water from the nearby Luggage Point wastewater treatment facility. The project is expected to reduce greenhouse gas emissions by some 90,000 tonnes of carbon dioxide equivalent per annum.

However, the scope and feasibility of cogeneration is not and should not be restricted to single point-of-use industrial processes and it should be considered for any form of development that has a reasonably constant requirement for both heat and power during a normal operating day and throughout all seasons.

Some typical smaller scale developments where cogeneration has proved successful are hospitals, hotels, institutions and swimming complexes. The scope for cogeneration in the commercial sector can be increased further with the incorporation of an absorption chiller which generates chilled water from the waste heat produced by the cogeneration plant (see Boxes 7.9 and 7.10).

Box 7.9: Macquarie University

Macquarie University, located north of Sydney, implemented a cogeneration project when the library was due to be expanded and the air conditioning upgraded. The cogeneration project, which was completed in September 2001, was constructed by Shaw Aiton Australia and incorporates two 760 kW generators, supplied by Energy Power Systems, and a 1300kW York chiller. A new plant room had to be constructed to accommodate the equipment, with provision made for the addition of an additional generator and chiller.

Heat produced from the engine's jacket and exhaust is used to heat the campus swimming pool, for space heating, domestic hot water and to drive the absorption chiller. The university uses all the power produced from the generator and continues to source electricity for its other needs from the grid. The plant operates unattended, with critical functions monitored by the campus building management system.

The greenhouse gas emissions from the university are reduced by 40 percent, or some 5,400 tonnes carbon dioxide equivalent per annum. The New South Wales Sustainable Energy Development Authority (SEDA) provided financial assistance to the project so that the university could meet its required rate of return on the investment.

Further scope for the Australian market may well be in the micro CHP field. In the European market, micro CHP units are currently being built and will be available by 2003. They are designed to be installed in the home to meet heat and electrical demands and replace household boilers (with surplus electricity being sold to the grid).[66] Whilst this is not a huge market within Australia perhaps, it is only a matter of time before "micro absorption chillers" become available and a Small Commercial/Domestic Trigeneration Plug and Power Pack would provide business/homes power, cooling and heating requirements at a reduced cost and greenhouse gas reduction.

Box 7.10: Trigeneration

Incorporating an absorption chiller increases the potential scope for cogeneration and effectively turns cogeneration into tri-generation (heat, power and cooling from a single energy source) therefore allowing the waste heat to be used year round and further greenhouse gas abatement realised. In cooling mode the coefficient of performance (COP) of the absorption chiller is 0.8 (ie, input of 1 kW of heat energy to obtain 0.8 kW cooling energy) as opposed to an electrically powered chiller that has a typical COP of 3 (ie, input of 0.33 kW of electrical energy to obtain 1 kW of cooling).

Greenhouse savings from this technology are twofold: first, lower emissions from using gas instead of coal for electrical generation and, second, avoided emissions from using waste heat to run the absorption chiller. While absorption chillers are less efficient than electric chillers, the absorption chiller runs from waste heat and thus avoids the need to generate additional electricity to power the electric chiller.

International Market

In the European Union, cogeneration accounts for approximately 9 percent of the generated power. In 1997, the European Commission called for a doubling of the market to 18 percent by 2010. While this is not legally binding, the growth of the cogeneration market will likely be realised with the ratification of the Kyoto Protocol.[67]

The current market in Europe is stagnant due to cogeneration being a victim of weak implementation of policy objectives, partial liberalisation of electricity and gas markets and rising oil prices.[68] However, there is new legislation in the offering (Completing The Internal Energy Market) that is estimated to come into effect by 2005. This legislation promotes small-scale cogeneration because calculation of the energy performance of buildings explicitly has to take into account the benefits of electricity generation from on-site cogeneration units and/or district heating. Member States are thus expected to design a calculation system that credits a better energy performance to buildings using cogeneration.

The American Market should double its cogenerated power production to 14 percent of total power generation by 2010. The American Council for an Energy Efficient Economy estimates that this capacity could be increased to 29 percent by 2020. This growth potential is ratified by the Bush Administration National Energy Plan released in May 2001 and is aimed at small-scale cogeneration, recognising the important role that

66 Jeremy Harrison et al, Cogeneration and Onsite Power Volume 1 Number 2 March-April 2000.

67 Whiteley, M, "Cogeneration's European Future" in *Cogeneration and Onsite Power Production,* Vol 2 Issue 4 July – August 2001.

68 Minnett, S, "Cogeneration in Europe" in *Cogeneration and Onsite Power Production,* Vol 3 Issue 4 July – August 2002.

cogeneration can play in meeting national energy objectives and maintaining comfort and safety in commercial and office buildings.[69]

Market Analysis: Conclusion

The principle of cogeneration is not new and has been available and employed for around 100 years. There are many different technologies available, reciprocating engines, gas turbines, fuel cells and waste gas technologies to name but a few. However, perhaps the biggest impact in terms of greenhouse gas abatement in the short term, say over the next 50 years, could be in the uptake of decentralised natural gas cogeneration plant. Although burning natural gas still produces CO_2-e, these emissions are less than the current central power and stand-alone heat generating plant. In this respect, gas-fired cogeneration systems could be viewed as a transitional technology that is available today that could help Australia and the world as a whole realise their greenhouse gas abatement goals until such time as renewable sources of energy are developed, readily available and the technology affordable.

7.3.4 Government Support Policies

Australia has a number of initiatives and programs in place to encourage the uptake of cogeneration systems. One such initiative is the Cogeneration Development Program run by SEDA in conjunction with AEA, Australian Pipeline Trust, Energex and Country Energy. The program funds and supports feasibility studies into the application of gas-fired cogeneration in NSW and covers the technical and commercial aspects of cogeneration at a potential user's site. Through its Cogeneration Investment Program, SEDA has also provided financial assistance to projects so that they could come to fruition and reach their required rate of return (as highlighted in Box 7.7).

The AGO's Greenhouse Gas Abatement Program $400 million of funding and targets large-scale and cost-effective greenhouse gas abatement programmes. The program is designed to run over 4 years and is currently in its second round. Under round one, there were a number of awards for cogeneration projects.[70]

7.4 Dry Agricultural Wastes

7.4.1 Technology Description.

A typical dry agricultural waste is cotton trash, a by-product of the cotton ginning process. Cotton trash comprises stalks, leaves, seedpods, some cotton residue and fine particles, with a moisture content of 5 to 8 percent. A large gin will produce around 50,000 tonnes of cotton per year, and around 10,000 tonnes of cotton trash.

The current treatment and disposal method for the trash material is onsite composting. The trash is conveyed to the composting field and is deposited in windrows. The windrows are periodically turned and the moisture content controlled to promote breakdown of the material.

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69 Hinrichs, D, "Cogeneration in Europe" in *Cogeneration and Onsite Power Production*, Vol 3 Issue 4 July – August 2002.

69 Cogeneration industry support program – media release 28 March 2001.

Disposal of cotton trash is a major problem.

The composted material is stockpiled onsite and made available for external sale. In most cases, the farmer does not use the composted material on farm due to the potential risk of disease propagation (primarily “Fusarium Wilt”). Potential dust, disease and residual pesticide issues have prompted the Environment Protection Authority of NSW to designate the composted trash as a “hazardous” material.

Waste Disposal Options

The main options for the disposal of cotton trash are:

- composting;
- incineration; and
- thermochemical processes (pyrolysis and gasification).

Each of these options has advantages and disadvantages as discussed below.

Composting

Composting of waste is currently extensively used by the cotton industry for the disposal of cotton trash. The process is relatively expensive, takes up a considerable area and is not particularly successful as the rate of decomposition is relatively slow. More positive disposal options would be preferred if cost effective.

Incineration

The incineration of cotton trash could be a practical method for the disposal of cotton waste. The main disadvantages when compared to thermochemical conversion processes (pyrolysis and gasification) are the low fuel economy and heat recovery and the need for more sophisticated exhaust-gas cleaning equipment. Where heavy metals are present in the feed, they will be incorporated into the char/ash residue and become a disposal problem, as they are leachable from the char/ash. Without effective heat recovery, incineration is not attractive.

Thermochemical Processes

Thermochemical processes include:

- liquefaction;
- pyrolysis; and
- gasification.

Liquefaction is a low-temperature, high-pressure conversion of wastes, usually with a high hydrogen partial pressure and a catalyst to enhance the rate of reaction. The main product from biomass liquefaction is oil with a heating value of 35 – 40 MJ/kg, suitable for power generation. Some systems provide for the solvent extraction of the oil. The cost of the system and the complexity of the system make it unattractive for the processing of cotton trash.

Pyrolysis is the thermal degradation of waste under anoxic conditions at temperatures between 400^{o}C and 800^{o}C at ambient pressure. The products of pyrolysis are:

- solid char comprising over 90 percent carbon;
- water;
- water soluble acids and methanol;
- insoluble tars; and
- gases, including H_2, CH_4, CO, CO_2 and N_2 (the gases produced vary with the temperature of the process).

Where heavy metals are present in the waste being processed, control of the temperature below 500^{o}C to 600^{o}C will retain the heavy metals within the solid pyrolysis residue. These low leaching residues can be disposed of to normal landfills. The control of temperature will also control the formation of dioxins; NO_x formation can also be suppressed.

Pyrolysis produces water-soluble hydrocarbons, tars and gases. It is difficult to recover the heat value from these products. The tars are particularly difficult to handle and pass through burners. These problems are overcome by gasification.

Gasification follows pyrolysis and is the oxidation of carbon and the cracking of tars and gases at temperatures of 800^{o}C to 1,400^{o}C. This is achieved by:

- introducing air (oxygen) to the reaction vessel for partial combustion of the products, with an associated temperature increase; or
- the further addition of heat to the vessel.

The source of oxygen can also be steam. This reaction is endothermic and, without the addition of further heat to the vessel, results in a temperature drop. The addition of steam reduces the solid carbon (char) and produces CO and H_2.

The gas produced by gasification contains H_2, CH_4, CO, CO_2 and N_2, trace amounts of higher hydrocarbons and various contaminants such as char particles, ash, tars and oils; the tars and dust must be removed from the product gas stream.

The product gas stream is referred to as ‘syngas’, which can be used to provide heating through a boiler/heat exchanger configuration, or used in a combustion engine to produce electricity. The pyrolysis/gasification process should provide sufficient syngas to meet the energy needs of the cotton gin.

The principles of pyrolysis and gasification have been known for over a hundred years. However, the design of such plants is complex and there are many abandoned pyrolysis plants throughout the world. In Europe, there are a number of suppliers with multiple plants running successfully. In Australia, there are only a few suppliers/designers with the capability and experience to manufacture a pyrolysis/gasification plant.

7.4.2 Greenhouse Gas Abatement

The recovery of energy from the pyrolysis/gasification of cotton trash is capable of reducing greenhouse emissions by up to 90 percent — LPG will still be used to initiate the pyrolysis process — and provide the energy needs of the gin, thereby significantly reducing the operating cost of the ginning process. The process will also prevent the spread of disease from the cotton trash and will destroy residual pesticides.

7.4.3 Market Analysis

Domestic Market

All Australian cotton gins have problems with the disposal of cotton trash. The development of a low-cost pyrolysis/gasification plant for cotton gin waste that provided the heat necessary for the ginning process would be welcomed by the industry. Potentially all Australian cotton gins are a market for this product.

International Market

The Australian cotton industry is small by international standards. Most overseas cotton gins have similar problems to Australia. The potential overseas market for a low cost pyrolysis/gasification plant for cotton gin waste that provides the heat necessary for the ginning process is very large.

Market Conclusion

All cotton gins require heat for the drying of cotton in the cotton ginning process. This heat could be provided by the pyrolysis/gasification of cotton trash. Most cotton ginning plants both in Australia and overseas would be a potential market for a low-cost plant.

7.4.4 Government Support Policies

A Demonstration Plant is under design for the Auscott cotton ginning plant at Narrabri in northwest NSW. Funding assistance is being provided by SEDA. The early completion of this project should be encouraged.

7.5 Wind

7.5.1 Technology Description

Wind power generation is the process of harnessing the wind's energy through wind turbines, which when collectively located, are termed Wind Farms.[71] Wind turbines convert wind energy by forced rotation of the turbine blades from the movement of the wind. The mechanical movement of the blades drives the turbine generator and this converts the energy into electricity. Wind farms range in scale and turbine height, with turbines typically standing between 50 to 80 metres high. Some wind turbines store the energy that is generated in batteries and others are connected to the grid or provide direct supply to communities. There are a variety of wind turbines with differing levels of mechanical complexity, the selection of which is largely governed by the local conditions of the area in which they are to be sited. Some have gears to optimise electricity

71 AusWEA Wind Power Fact Sheet

generation. Depending on the scale of the turbine and the wind patterns of the location, there might be a sophisticated directional system to align the blades into the best wind path to maximise the potential to harness the energy. Likewise, many turbines have an inbuilt protection system to safeguard against damage in the event of high winds, which may involve simple reorientation of the blades, mechanical brakes or even mechanical shut–down systems.

Wind power is generally proportional to wind speed to the power of three, hence, the windier a site is, the more power is available for harvest.[72] Apart from the actual wind speed at a site, the length of the blades on the rotor of a wind turbine also dictate the power that can be harnessed from the wind, the longer the blade, the more power it will exploit. Different types of turbines operate at their optimal level at different wind speeds, largely to suit the conditions of the site. The best wind turbines operate at a 35-40 percent capacity factor (due to variable wind resources).

Wind farms are best suited to sites that are subject to strong consistent winds. To be economical, the Australian Wind Energy Association (AusWEA) indicates that 7m/s or 25km/h at hub height is needed for large-scale wind turbines. Therefore, it is imperative that accurate assessment, monitoring and modelling of wind yields are carried out to further the economic development of wind energy. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) recommend assessment at regional, local and site-specific levels to accurately gauge the returns available at potential sites.

7.5.2 Emissions Abatement

Wind power generated electricity represents a ‘clean’ renewable technology. Apart from the initial power consumption needed to manufacture and install the turbines and any production of replacement parts necessary during the lifetime of the turbine, there are no emissions directly generated from this technology.

Wind energy can be viewed as a substitute for conventional energy production, such as coal-fired generated electricity, and therefore reduces greenhouse gases emissions associated with that technology. For every megawatt hour (MWh) of renewable energy generated, the emission of approximately 1 tonne of carbon dioxide (CO_2) through coal-fired electricity generation is displaced.

According to the AusWEA, a modern wind turbine can produce enough energy to meet the needs of several hundred homes and save up to 3,000 tonnes of CO_2 emissions per year.

In addition to reducing GHG emissions, wind generated power also avoids the emission of other pollutants associated with conventional energy supply, thus benefiting regional air quality. It also avoids the land use and water quality impacts associated with mining. Being modular in nature, wind farms are able to be located near loads within the low voltage distribution network (assuming adequate wind resources), thus avoiding transmission losses and capital expenditure associated with transmission networks. Wind farms also create a new income stream for rural landholders.

72 CSIRO website.

7.5.3 Market Analysis

General

Wind generated power is one of the world's fastest growing renewable energy sources. It has grown at an average rate of 25 percent per annum over the last decade.[73] Ninety percent of new wind generation facilities installed worldwide are located in Europe.[74] In 2000, approximately $US4 billion was invested in installations globally. Approximately 6,500MW of capacity was installed in 2001, representing sales of approximately $7 billion. Regulatory and other support for wind energy, as well as increased consumer demand for 'green energy' in recent years has become a key driver for renewable energy technologies such as wind energy.

Current Australian Market

National Level

The geographical location and climate of Australia is favourable for the development of wind power generation. The prevailing winds to the south of the country make South Australia, Victoria, Tasmania and south-west WA ideal locations for wind farms. The expanse of coastline exposes this southern region to some of the strongest winds in the world. All states in Australia have some potential for wind-generated power.

SEDA has estimated that there is the potential for approximately 1000 MW of wind power generation in NSW alone. Some areas of NSW have wind speeds comparable to coastal sites in southern Australia. Strong wind speeds arise in the State due to the interaction of hills and ridges with the background winds blowing from west to east across the State.

Stronger wind speeds are generally found along the Great Dividing Range. Some of the windiest areas in the State are the Snowy Mountains, the areas north of Goulburn, west of the Blue Mountains and north of Armidale with wind speeds ranging from 7 to 12 metres per second (m/s). The highest measured annual average wind speed appears to be at Mount Kosciusko and was recorded at 12 m/s.

Over the last five years, the domestic wind energy industry has grown substantially. As at June 2000, according to the IEA, electricity generated from wind energy accounted for 0.04 percent of total electricity generated in Australia.[75] While starting from a low base, growth has been rapid. Australia had 34MW wind capacity at the start of 2000 and 73 MW at the start of 2001. This represents growth of 215 percent. The IEA predicts a huge increase in installed capacity by 2005. The AGO projects that there will be an annual contribution of grid connected wind power in the order of 1000GWh/yr from an installed capacity of 500MW by 2010.

73 Dr Stephen Schuck, *Sustainable Energy Innovation, a new era for Australia,* 2002.

74 AWEA, Global markets report 2000, *Press release,* 9 February 2001 AusWEA website.

75 International Energy Association, IEA, R & D Wind Annual Report 2001 – National Activities for Australia

In Australia, there are a few market leaders in the large scale wind farm industry; Pacific Power International, Pacific Hydro Ltd, Western Power Corporation, Stanwell Corporation Ltd and Hydro Tasmania. This expertise is currently limited to the design, installation and operation of wind turbines, as currently wind turbine components are largely manufactured in Europe and imported to Australia. Table 7.3 below, illustrates the domestic position by showing wind farms in operation in Australia as at the end of 2001 and Table 7.4 illustrates large-scale wind farms which are planned for future development.

Table 7.3: Wind Farms in Operation in Australia at the End of 2001

Location	No. of outputs	Capacity (MW)	Application
Albany, WA	12 x 1800kW	21.6	Grid Connect
Denham, WA	3 x 230kW	0.69	Wind Diesel
Salmon Beach, Esperance, WA	6 x 60kW	0.36	Wind Diesel
10 Mile Lagoon, Esperance, WA	9 x 225kW	2.025	Wind Diesel
Murdoch, NSW	1 x 20kW	0.02	Research
Armidale, NSW	1 x 30kW	0.03	Grid Connect
Blayney, NSW	15 x 660kW	9.9	Grid Connect
Crookwell, NSW	8 x 600kW	4.8	Grid Connect
Hampton Hill Wind Park, NSW	2 x 660kW	1.32	Grid Connect
Kooragang Island, NSW	1 x 600kW	0.6	Grid Connect
Breamlea, VIC	1 x 60kW	0.06	Grid Connect
Codrington, VIC	14 x 1300kW	18.2	Grid Connect
Flinders Island, TAS	1 x 55kW	0.055	Wind Diesel
Flinders Island, TAS	1 x 25kW	0.025	Wind Diesel
Huxley Hill, TAS	3 x 250kW	0.75	Wind Diesel
Thursday Island, QLD	2 x 225kW	0.45	Wind Diesel
Windy Hill, QLD	20 x 600kW	1.2	Grid Connect
Coober Pedy, SA	1 x 150kW	0.15	Wind Diesel
Harbour Point, SA	2 x 5kW	0.01	Standalone
Epenarra, NT	1 x 80kW	0.08	Wind Diesel

Source: Australian Wind Energy Association, website and International Energy Agency, *Annual Report – National Activities for Australia,* 2001

Table 7.4 Planned Large Scale Wind Farms

Location	No. of outputs	Capacity (MW)	Application
Boral Energy, SA	Undecided	5 MW	Grid Connect
Port Headland Project	120	180MW	Grid Connect
Cape Bridgewater, VIC	Undecided	Undecided (approx 50MW)	Grid Connect
Cape Nelson, VIC	Undecided	Undecided (approx 65 MW)	Grid Connect
Cape Sir William Grant, VIC	Undecided	Undecided (approx 12 MW)	Grid Connect
Yambuk, VIC	Undecided	Undecided (approx 25MW)	Grid Connect
Challicum Hills, VIC	Undecided	Undecided (approx 75 MW)	Grid Connect
Windy Hill, Phase 2, QLD	Undecided	13	Grid Connect
Lake Bonney, SA	41	Undecided (approx 60 MW)	Grid Connect
Tungketta Hill, SA	Undecided	50 MW	Grid Connect
Woolnorth, TAS	6 x 1.75MW	10.5 MW	Grid Connect
Toora, VIC	12 x 1.75MW	21 MW	Grid Connect

Source: Australian Wind Energy Association website

State Level

SEDA has identified NSW as having a good wind resource and has set a target of 1,000MW of wind generation capacity. To assist in achieving this target, the NSW Government has produced a wind energy handbook, held a series of network planning forums with local communities, developed environmental planning guidelines for wind energy, and established 26 40 metre wind monitoring towers across the State. TransGrid and Country Energy are also working with industry in a coordinated approach to connect wind developments to the electricity grid.

A $1.5 million wind-mapping project has produced data to be used by electricity generators, retailers and landowners. A newly released wind atlas maps the State's wind speeds, the relationship with local terrain and the location of the State’s high voltage transmission network. More detailed regional reports are also available including information regarding native vegetation and national parks, native title claims etc. (For further detail, refer to the Wind Manufacturing Case Study, a stand alone document prepared in conjunction with this Report.)

It is estimated that wind energy has the potential to supply more than 2,200GWh of electricity, which could reduce NSW carbon dioxide emissions by 2.4 kt of CO_2-e per year.[76]

Case studies

Two wind generation case studies are presented in Boxes 7.11 and 7.12.

Box 7.11: Crookwell Wind Farm

A joint venture by Pacific Power and Great Southern Energy in 1998 saw the establishment of Crookwell Wind Farm in rural NSW. The site has 8 Vestas 600kW turbines, producing and supplying 4.8MW of electricity to the grid, when running at capacity.

CSIRO Land and Water research assisted Pacific Power and Great Southern Energy in establishing the best location for the turbines and forecasting the potential yields.

76 SEDA Website

The project displaces 8,000 tonnes/yr of CO_2 emissions.

Box 7.12: Portland Wind Energy Project

The Victorian Government gave approval to Pacific Hydro Ltd to develop a $270 million wind farm facility at Portland, VIC, in August 2002. The wind farm will consist of 120 wind turbines spread over 4 sites in southwest Victoria; Cape Bridgewater, Cape Nelson, Cape Sir William Grant and Yambuk. It will have the combined capacity to generate 180MW, which will make it the country's largest wind farm.

Pacific Hydro Ltd has identified a number of environmental, economic and social benefits that they anticipate will arise from the project:

- 800,000 tonnes/yr of avoided greenhouse gas emissions through substitution of coal-fuelled electrical power supply with wind generated electricity;
- electricity supply to 100,000 homes;
- establishment of a wind turbine manufacturing and assembly industry creating up to 2000 jobs, with the potential to become the new manufacturing centre of Australia and South East Asia;
- a $100million injection to local economy;
- export market development – with an estimated value of $100million/yr;
- reduced reliance on imports for the Wind energy industry, estimated to avoid $900million expenditure over 5 years; and
- tourism opportunities

Source: Pacific Hydro Ltd website

International Market

There has been steady growth in wind power generation in Europe, the region currently leading the world in wind power installations. This steady growth has led the European Wind Energy Association (EWEA) to increase its own targets. According to the EWEA, Europe currently has approximately 25,000 MW of installed wind capacity. In 1999, they released a report indicating how wind power could meet 10 percent of the world's energy needs by 2010. They have subsequently released a report revising this figure to 12 percent.

Germany holds the position of world leader, with an installed capacity of 8,753 MW as of the start of 2002 (up from 6,113MW as at 2000). Table 7.5 shows the world ranking in terms of installed capacity as at 2000 and the national targets for wind energy production.

Table 7.5: International Position in Wind Generation Capacity, 2000 and National Targets for Wind |Energy

Ranking	Country	Installed Capacity (MW)	National Target for Wind Energy or renewable energy
1	Germany	6,113	(To reduce carbon dioxide emissions by 25percent (1990 baseline) by 2005).
2	US	2,554	60,000MW by 2020
3	Spain	2,250	8,974MW from wind energy (12percent primary energy demand from renewables by 2010)
4	Denmark	2,140	1,500MW by 2005 5,500MW by 2030 of which 4,000MW is offshore
5	India	1,167	No data available
6	Netherlands	449	1,500MW by 2010 7,500MW by 2020
7	Italy	420	Approx 2,500MW by 2010
8	United Kingdom	400	(Increase electricity supplied from renewables by 5percent by 2003 and 10percent by 2010, subject to consumer acceptance of cost)
9	China	265	No data available
10	Sweden	226	0.7TWh per year by 2002

Table 7.6 shows wind capacity in 2002, indicating its rapid growth since 2000.

Table 7.6: Operating Wind Capacity as at January 2002

Country	MW	Country	MW
Germany	8753	Egypt	125
USA	4245	Ireland	125
Spain	3335	Austria	95
Denmark	2417	France	85
India	1507	Australia	73
Italy	697	Costa Rica	71
UK	485	Morocco	54
Netherlands	483	Ukraine	40
China	399	Finland	39
Japan	300	New Zealand	37
Sweden	280	Belgium	31
Greece	272	Poland	28
Canada	207	Turkey	19
Portugal	127	Norway	17

Source: http://www.wpm.co.nz/windicat.htm

Many countries have set challenging targets in an attempt to increase electricity production from wind energy and other renewable resources to reduce their reliance on non-renewable fuels and to reduce the level of greenhouse gas emissions associated with those fuels.

An interesting international trend is the rising development of offshore wind energy installations. The main driving forces leading countries to consider offshore developments are limited available on-shore sites due to land space, public opposition to wind farms and maintaining proximity to demand.

There are a variety of market drivers utilised globally. The main mechanisms appear to be:

- fixed tariffs;
- tax incentives or obligations to producers and/or users to source electricity from renewable sources; and
- a system of open market trading of 'green' certificates to meet targets set for the proportion of energy that must be met from renewable sources.

Other drivers include changes to national environmental policy, investment in research and availability of grants and subsidies. For example, in the US, as indicated in the International Energy Association R&D Wind Annual Report, 2001, there is a federal subsidy of 0.017 US$/kWh payable via tax credits or production incentive payments to wind energy producers. In the UK, The Climate Change Levy, introduced in 2001, provides an incentive for businesses to source their electricity supply from renewable technologies by placing a charge of 0.43p/kWh on electricity from non-renewable sources.

The New Zealand Government has recently confirmed its package of policy measures on reducing GHG emissions, including a 30 PJ renewable energy target. New Zealand has strong wind generation potential but no local manufacturing capability. State owned generator Meridian Energy intends to develop 200 MW of wind capacity in coming years (2-3 wind farms comprising 1.75 MW units).[77] Another company has proposed a NZ$35 million wind farm near Wellington.[78]

A number of constraints to market development of wind energy exist, both in Australia and in other countries. These include:

- the low cost of conventional forms of electricity;
- the availability of suitable sites;
- the difficulty in obtaining planning consent due to public opposition on the grounds of loss of visual amenity, effects on flora and fauna, particularly bird migration, noise, electromagnetic interference etc;
- the distance from electricity grids — often the best wind farm sites are in remote locations;
- electricity grid limitations;
- problems with certification of wind turbines in differing climatic conditions; and
- unpredictable supply.

77 Marta Steeman, "Meridian plans wind farms to offset power shortage", Waikato Times, 19 October 2002.

78 "$35m windfarm for Wainuiomata planned", Waikato Times, 19 October 2002. http://www.stuff.co.nz/stuff/waikatotimes/0,2106,2084607a13,00.html

Some countries are looking at the potential for combined generation, for example, the UK and Germany are considering combined wind power and natural gas or landfill gas to improve the certainty of electricity supply. To address the planning constraints, many countries are developing policy and guidelines on the siting and/or operation of wind farms, including Australia, where at a state level, Victoria has issued Policy and Planning Guidelines for development of wind energy facilities and NSW has produced environmental planning guidelines for wind energy and a wind energy handbook.

Market Conclusion

There is great potential to develop wind power generation in Australia. It has the potential to become a significant provider of renewable energy to meet Australia's MRET target for 2010 (see below). As the number of wind farms increase, the cost per unit will fall. With the news of the approval of the Portland wind farm in Victoria, which incorporates plans for a manufacturing and assembly facility, there is further indication that the establishment costs associated with wind farms will reduce due to local market supply and reduced import costs. Pacific Hydro Ltd is set to establish manufacturing facilities for large wind turbines in Australia and aims to not only supply the growing demand from the Australian market but also service the growing Asia-Pacific market. For many planned wind farm developments, this market development would lift the cost barrier posed by imported wind turbine components.

7.5.4 Government Support Policies

Developments and Initiatives

Existing development and initiatives include:

- the Office of the Renewable Energy Regulator (ORER) was established in February 2001 to administer the Mandatory Renewable Energy Target as set out in the *Renewable Energy (Electricity) Act 2000*;
- the Australian Cooperative Research Centre for Renewable Energy (ACRE) was established in 1996 to aid the development of renewable technology (however an application for ongoing funding for ACRE was rejected in late 2002 by the Commonwealth Government);
- the Wind Energy Research Unit at CSIRO Land and Water runs 24 monitoring towers in NSW as part of the wind monitoring program run by SEDA;
- the National Green Power Scheme;
- SEDA's NSW Wind Energy Handbook aimed at key stakeholders in the wind energy market; developers, landowners, local government and the wider community; and
- SEDA's NSW Wind Atlas based on the data collected from the NSW wind-monitoring network. More detailed regional reports are also available for purchase. These provide higher resolution information and detail about related infrastructure, land use, etc.

Research and Development

Research into various aspects of Wind Energy Technology is carried out at the following Australian Institutions:

- University of Technology, Sydney;
- Energy Research Institute at Murdoch University;
- University of Newcastle;
- NT University;
- Curtin University of Technology;
- University of Queensland;
- ACRElab;
- Centre for Renewable Energy Systems Technology Australia (CRESTA); and
- Wind Energy Research Unit at CSIRO Land and Water.

7.6 Solar Photovoltaic (Grid Connected)

7.6.1 Technology Description

Photovoltaic (PV) or solar cells are constructed of semiconductor material such as silicon (the most commonly used material for PV cells), which is placed into a glazing system for protection and to facilitate installation. Cells are electrically interconnected within each glazing module and between modules to form a PV array. This array interconnects to the electrical load via safety devices, inverters and other intermediate components as required to create the entire electrical system.

When light energy strikes the PV cell, the semiconductor absorbs some of the energy, which knocks electrons loose, creating electrical motive forces that can be channelled for useful purposes.

PV cells, modules and arrays come in various forms for example:

- cells can be:
  - Monocrystalline, meaning a single crystal of silicon per cell. This causes each glazing/PV module to have a chessboard appearance;
  - Multicrystalline or Polycrystalline allows larger but less efficient cells; glazing/PV modules have a specular appearance;
  - thin film cells are formed by depositing thin layers of conductive and semiconductive materials onto a surface that can be a building material other than glass (eg, roof sheeting). This type is also referred to as amorphous cells. Amorphous panels are a commercially available example of this technology;
- arrays can be flat allowing light to strike them in its natural plane or may incorporate some form concentration to direct larger amounts of light toward the array. Concentration may include reflectors, lenses etc. but may also form part of the glazing system such as grooves cut into an otherwise flat system;

- systems with independent framing and building integrated PV (BIPV) arrays where arrays essentially replace building fabric to match the orientation of the built form — see Figure 7.2; and
- arrays can be grid connected, where electricity is fed to the grid as it is generated, or stand-alone (also called Remote Area or RAPS), where electricity is stored in batteries for later use.

The types and arrangements of this technology are large and continually growing due to continued research and development around the world.

Figure 7.2: Multi-Crystalline Array at the University of Melbourne

7.6.2 Emissions Abatement

Once manufactured and installed the cells require nothing other than sufficient light to drive the photovoltaic processes, cell life is currently 20 to 30 years with some components of the electrical system (inverters) having a reduced life of around 10 years. Once installed the renewable nature and reduced greenhouse gas emissions nature of this technology are obvious.

7.6.3 Market Analysis

General

Current world sales for solar electric systems are worth one billion euro per year and the annual growth rate for the next decade is expected to be around fourteen percent. Shell Renewables, one of the five core businesses in the Shell Group, predicts a rise in this rate to 22 percent and annual cost reductions of six percent. In a detailed 1995 planning scenario for three decades from now (Energy in Transition), Shell predicted that PV will be the most rapidly growing form of commercial energy after 2030, with annual sales exceeding 100 billion euro. [79]

79 http://www.eurec.be/htm/projects

Domestic

The Australian PV market is dominated by remote area applications where PV systems displace small diesel powered plants (for example) and where solar energy is reliable in large quantities and requires little maintenance, and where other sustainable energy sources (eg, biomass, hydro, wind) are scarce or unreliable. The Commonwealth's Photovoltaic Rebate Program is a primary driver of the introduction of PV systems in the major urban centres. These systems are not only connected to the immediate electrical installation but are also connected to the grid to allow import of grid power as required and export of PV power if available.

Research is being performed on PV cells and systems at the Key Centre for Photovoltaic Engineering — see Box 7.13 — Photovoltaics Special Research Centre and Special Research Centre for Third Generation Photovoltaics; University of New South Wales; Australian National University operates the Centre for Sustainable Energy Systems and Murdoch University hosts the Cooperative Research Centre for Renewable Energy and Greenhouse Gas Abatement.

On the manufacturing front, BP Solar and Solarex have manufactured cells in Australia since the 1980's; these companies have now merged to form BP Solar. Australian manufacturing amounted to approximately 7.7MW of cell output in 2001 and plans for expansion to 25 MW per year have been reported.

Pacific Solar is developing a uniquely Australian thin-film polycrystalline silicon on glass technology (pilot production) along with commercial scale assembly of imported modules into their innovative 'plug and power' technology.

Another company, Solar Systems Pty Ltd, has developed photovoltaic dish concentrating systems, demonstrating some of the highest field efficiencies yet reported (approaching 20 percent). Solar cells are also manufactured for sale by some of the research facilities.

Box 7.13: Key Centre for Photovoltaic Engineering UNSW

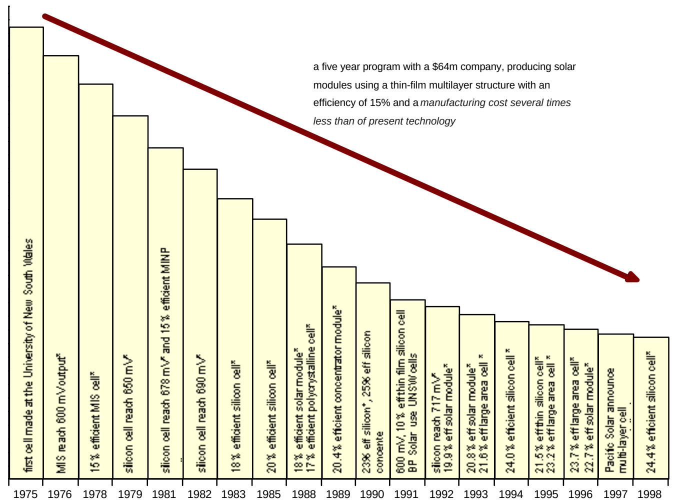
The Photovoltaics Special Research Centre was established at the University of New South Wales in 1990 with founding grants from the Australian Research Council and Pacific Power. Professor Martin Green, who began developing solar cells at UNSW in the mid-1970s, heads the group. Growing interest in sustainable technologies has spurred the growth of the group, which now has about 70 staff and students.

The main researches at the Centre are high efficiency solar cells, buried contact solar cells, thin film solar cells, and photovoltaic systems. Nearly all device research is based on the semiconductor silicon. Systems research areas investigated include static concentrator roof tiles, inverters (interface DC output of solar cells with AC systems), grid connection, site selection, remote areas power supplies, institutional issues and building integration.

Major successes include buried contact solar cells licensed to most of the world's major solar cell manufacturers such as BP Solar, and Pacific Solar, establishment in collaboration with Pacific Power in 1995. The five year program of this $64 million company is to develop commercial solar modules using a thin-film multi-layer structure, with an efficiency of 15percent and a manufacturing cost several times less that of present technology. The Centre also had success in solar car races such as the World Solar Challenge.

Since the Centre's laboratories began their research in 1974, many important results have been achieved. Some of the milestones achieved can be presented by the following graph:

Achievements by the Centre for Photovoltaic Engineering UNSW

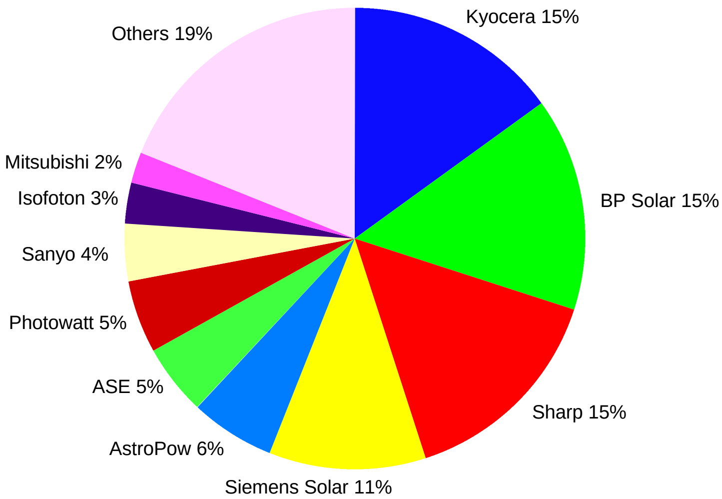


Source: http://www.pv.unsw.edu.au/info/pvceinfo.html
* Indicates world first

International

There are literally hundreds of photovoltaic manufacturers around the world, some major players are indicated in Figure 7.3.

Figure 7.3: Photovoltaic Manufacturers: 2000 World Market Shares of the 'Top Ten'



Source: Project Company Solar Energy Systems GmbH (Projektgesellschaft Solare Energiesysteme mbH)

The market for photovoltaics has shown strong growth rates for many years. From 1990 to 1999, the world market for photovoltaic modules grew by an annual 15 percent, and this has increased since 2000 to a rate reportedly as high as 40 percent. Total sales volume around the world is currently approximately US$1 billion per year and the total performance of all systems installed in one year is 280 Megawatts.[80]

The photovoltaic industry in the United States created a 'PV Industry Roadmap' published January 1, 2000 setting forth goals over the next 20 years. The roadmap created a blueprint of research, technology, and market priorities needed to accomplish long-term PV industry goals to:

> "realise a thriving United States-based solar-electric power industry, which provides competitive and environmentally friendly energy products and services that meet the needs and desires of the domestic electric-energy consumer."

The US industry looks to install 6 gigawatts peak (GWp) worldwide and lower the cost to end-users to be economically competitive with conventional technologies by 2020. To reach the above goal of installing 6 GWp power worldwide by the year 2020 would require an 80-fold increase in growth from 2000 levels.

Market Conclusion

Photovoltaic cell technology has some issues to overcome including high implementation costs in the lead up to operation. Nevertheless, it is a major renewable/sustainable energy technology that will see continued large growth throughout Australia and the world in the foreseeable future. The technology benefits from the following attractions:

- it can be installed easily virtually anywhere from small residential rooftops to centralised solar farms;

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80 http://www.solarserver.de/solarmagazin/artikel_mai2001-e.html

- no noise;
- low maintenance;
- there are no by-products of energy production and the technology carries a 'clean green' image, avoiding not only GHG emissions but also emissions of other pollutants associated with conventional energy supply;
- it can be located where the energy is needed, thus avoiding transmission and distribution losses, reducing capital expenditure on network capacity and promoting a more diverse and secure supply system;
- it is easily understood as a technology harnessing a major natural and renewable resource; and
- although current costs remain high, the mass production levels of PVs in the near future will drive the costs down to more affordable levels.

7.6.4 Government Support Policies

The major world players in the PV market are Japan, USA and Germany. This capability has grown out of strong government initiatives coupled with large domestic markets in order to build self-sustaining local markets, mass production economies of scale and associated market dominant positions.

When it comes to building integrated PVs (BIPVs), demand for the technology continues to grow with the support of a variety of individual country programs:

- the European target for BIPVs is around 1,300 MW by the year 2010;
- Japan hopes to reach 4,600 MW (see Box 7.14); and
- the US has planned a 1 million rooftop program (see Box 7.15).

This compares with current total world BIPV installations of around 580 MW[81] and 1,200 MW for all photovoltaic systems.[82]

81 M. Watt, R. J. Kaye. D. Travers & I. McGill, *Assessing the Potential for PV in Buildings*, Photovoltaics Special Research Centre UNSW.

82 European Photovoltaic Industry Association.

Box 7.14: Photovoltaics in Japan

Japan is becoming a major world player. Japan's global market share exceeded 40 percent in 2000. One reason Japan achieved prominence is federal assistance primarily via the Ministry for the Economy, Trade, and Industry (METI). With help from the research program "New Sunshine Project" started in 1993 and the incentive program "Residential PV System Dissemination Program" began in 1994, the Japanese have been able to build up a self-supporting market. With the commercialisation of PVs at the forefront of the objectives, the Japanese industry aims at mass production by 2005. At that point, companies could offer their products to the world markets at lower prices and efficiently win market shares due to a considerable sustainable market advantage.

Under the Residential Program, METI promotes the installation of solar power systems on private rooftops. Often described as the 70,000 Roofs Program, this promotion is to stimulate demand. Statistics provided to the International Energy Agency state that the Japanese roof program had promoted 51,899 solar power systems to March 31, 2001. The capacity of these systems amounts to about 210 megawatts and the maximum output of all such systems installed in Japan up to this point was 317.5 MW.

Source: http://www.solarserver.de/solarmagazin

Box 7.15: USA Million Solar Roofs

On June 26, 1997, in a speech before the United Nations Session on Environment and Development, President Clinton announced an initiative to install solar energy systems on one million U.S. buildings by 2010. Run by the US Department of Energy (DOE), the million solar roofs program represents a serious commitment by the United States Government to promote solar technologies.

When the initiative started, about 2000 buildings were utilising solar technologies. By the year 2000, close to 11,000 solar thermal and photovoltaic systems have been installed. Although a five-fold increase in three years, there are still many more installations that must be done over the next decade to meet the million solar roofs goal.

Although a federal initiative, the million solar roofs program is designed to assist states and local communities through collaborative ventures that bring business, government, the energy industry, and community organisations with a commitment to install a set number of solar energy systems. Close to 50 collaborative ventures have committed to install more than another 900,000 systems before 2010.

There are many incentives for installing solar systems on a state-by-state basis and the Million Solar Roofs Initiative makes direct grants available. Currently, the DOE will be awarding 20-50 grants totaling $1,500,000 to existing and/or new state and local partnerships. Each grant will be limited to $50,000 and are intended to support development and implementation activities.

Source: http://www.solarserver.de/solarmagazin

The Australian Government supports renewable energy development through programs managed by the Australian Greenhouse Office. Two schemes have been implemented specifically in relation to PVs for residential and community buildings:

- the Photovoltaic Rebate Program (PVRP) provides $31 million in support for installation of photovoltaics. At October 2001, over 3,500 applications had been approved of which 837 (24 percent) involved grid-connected system;[83]

- the Renewable Remote Power Generation Programme (RRPGP), is a $264 million programme supporting the uptake of renewable energy in remote areas. RRPGP funds provide up to 50 percent of capital costs of installations, with Western Australia and Queensland providing an extra 5 percent and 15 percent rebate, respectively;

83 Martin A. Green, *Australian Photovoltaic Research and Development*, Centre for Third Generation Photovoltaics, University of New South Wales Sydney.

- the Renewable Energy Commercialisation Program (RECP) provides support for renewable energy industry development. This funding has gone to projects such as:
  - building integrated photovoltaics;
  - remote area demonstration projects;
  - the development of photovoltaic inverters and charge-controllers;
  - Solarex (now BP Solar) was awarded funding for improving multicrystalline cell efficiency;
  - Sustainable Technologies International was awarded funding for a nanocrystalline titania cell and panel manufacturing facility;
  - Pacific Solar was awarded funding for residential systems demonstrating thin-film polycrystalline silicon on glass technology;
  - in concentrating photovoltaics, Solar Systems Pty Ltd has been funded for design and manufacture of 20-24 kW photovoltaic dish systems; and
  - the development of the Solar Sailor, a unique 108-seat solar and wind powered catamaran for Sydney Harbour; and
- under the Renewable Energy Industry Development Program (REID), the ANU company, ANUTECH, has been funded to develop a 20 kW parabolic trough system. The Kogarah Town Square, which includes 160kW of fully roof-integrated solar power, was also funded under this program.

7.7 Mine Waste Gas and Vent Air Technology

7.7.1 Technology Description.

Coalmine methane (CMM) refers to a waste gas released from the coal or the surrounding strata in the underground coal mining process. The gas may also contain other hydrocarbon gases or constituent gases such as carbon dioxide, nitrogen or oxygen. Until recently this gas has been released into the atmosphere from both active mines and abandoned mines. CMM is directly related to the coal mining process and should be distinguished from coal bed methane (CBM) where methane trapped in coal seams is extracted specifically for production of sales quality natural gas.

Methane released from the coal in active mines was traditionally vented to the surface to avoid forming a potentially explosive atmosphere. A significant proportion of coal also remains in abandoned mines and methane continues to be released and must be vented to the surface in a safe manner to avoid uncontrolled escape creating hazardous conditions in the surrounding area. CMM takes about 50 to 100 years to decay to negligible levels compared with landfill gas, which takes about 20 years.

CMM Utilisation Technologies

CMM released into the atmosphere is a greenhouse gas that could otherwise be utilised as a valuable source of energy. This section presents a brief summary of technologies available to utilise CMM.

CMM with High Methane Concentration

CMM removed from coalmines through the degasification system of operating mines and CMM vented from abandoned mines typically has high concentrations of methane and may be utilised as fuel using technologies such as:

- *Natural Gas Substitution* — This method is practically similar to CBM and applies to cases where the gas is drained from pre-mine or in-seam boreholes. The method is economically feasible where the drained gas has a high concentration of methane (about 95 percent), requires modest processing to meet natural gas sales quality specifications and the mine is in close proximity to a natural gas pipeline or an accessible gas market.

- *Direct use of CMM* — CMM may be used directly as burner fuel within or close to the mine as a lower heating value fuel alternative to reduce the consumption of retail energy. The CMM may be fired separately or co–fired with coal or other fuels either within the mine in utility boilers, coal drying, heating or brine water evaporation or outside the mine where a nearby industry exists.

- *Electricity Generation* — There are various technologies which could use CMM directly or indirectly to generate electricity and depend mainly on the concentration of methane:

  – internal combustion engines can be adapted to produce electricity using CMM with concentrations of methane as low as 45 percent or probably lower as fuel;

  – modern gas turbines have successfully used CMM with concentration down to 35 percent to generate electricity; and

  – fuel cells operating with a solid electrolyte at about 80^{O}C use hydrogen and oxygen in an electrochemical reaction to create direct current. CMM may be used as feedstock to generate hydrogen. Fuel cell technology became commercially available in 1999.

Vent Air Methane

CMM vented from operating mines — known as vent air methane (VAM) — typically has gas methane concentrations between 0.3 percent and 1 percent, however, it comprises the largest proportion of mine gas greenhouse emissions. VAM cannot be used as fuel and miners have only made a few attempts to capture this gas. The following methods have the potential to utilise it as an energy source and to reduce greenhouse emissions:

- *Air Intake of Engines and Burners* — A fraction of ventilation air may be captured and used as air intake for combustion engines or burners thus supplementing the main fuel and reducing greenhouse gas emissions.

- *Oxidation of Methane* — Thermal flow reversal reactors and catalytic flow reversal reactors are two types of methane oxidation methods under development. The process generates heat by oxidation of the methane at high temperature and employs the principle of regenerative heat exchange between the gas (VAM) and a bed of solid heat exchange medium selected to store and transfer heat efficiently in the reaction zone. The technology has been proven on a small experimental scale and is yet to be proven on full scale.

Destruction or Flaring

Destruction or flaring of methane does not provide energy, however, it is noted herein as an option for reduction of greenhouse emissions where utilisation of CMM as an energy source is not economically feasible.

7.7.2 Greenhouse Gas Abatement

Methane is a greenhouse gas and its release into the atmosphere has a global warming potential 21 times greater than carbon dioxide. The capture and utilisation of CMM as fuel to produce energy offers a significant reduction in greenhouse gas emissions directly by consuming the CMM and indirectly by saving consumption of alternative traditional fuels. The use of CMM as fuel also reduces emissions of SO_X and NO_X compared to other traditional fuels.[84]

Waste CMM emissions account for approximately 4 percent of all greenhouse gas emissions in Australia and about 10 percent of greenhouse emissions in the USA.

Current technologies have the potential to utilise up to 95 percent of CMM emissions from active mine drainage and abandoned mine releases. However, the utilisation of the low concentration methane from mine air ventilation is yet to be captured and utilised effectively, although it is the major source of methane emission to the atmosphere.

7.7.3 Market Analysis

General

CMM offers an alternative energy source with reserves from an active or abandoned coalmine to last beyond 100 years. The economic success of projects that generate electricity from CMM also offers the potential for activity and growth in economically deprived mining communities especially around abandoned mines.

Below is a general overview and examples of current trends in the utilisation of CMM as a renewable energy source.

Operating CMM Projects in Australia

Australia has the most commercially advanced CMM and CBM industry outside the United States. Australia also has the largest CMM power project in the world at Moura Mine in Queensland.

Operational CMM projects include:

- the Moura Mine in Queensland established a commercial CMM business next to the coal mining operation in 1996. The project degasifies both from an underground and from a high wall mine. The gas is recovered five years ahead of mining, processed &

[84] GHD, personal communication.

compressed on site and delivered into the State Gas Pipeline as sales quality natural gas. The gas is also used as fuel in the onsite power plant;

- the Appin Tower Coal Bed Methane Project in NSW is expected to cut greenhouse gas emissions by 12 to 14 million tonnes between 2008 and 2012. The Appin and Tower Collieries, operated by BHP Billiton, produce electric power using drained CMM as fuel in 94 x one-megawatt engines. Additionally, 54 of the engines located at the Appin site use mine ventilation air as the combustion air (vent air technology). The project has operated at full capacity, 365 days a year, since 1996. The project achieves 3 million tonnes per year of carbon dioxide equivalent reduction making it one of the largest greenhouse gas reduction projects in Australia; and

- Envirogen's Tahmoor Colliery Project uses five 1MW gas engines to produce power from CMM drained from the mine. This project commenced operations in 2001 and uses natural gas to enrich the fuel if the concentration of methane falls below that acceptable to the engines.

Planned CMM Projects in Australia with Government Funding

The following CMM projects will receive about $54 million under the Commonwealth Government's Greenhouse Gas Abatement Program.

- *West Cliff Colliery in NSW* — BHP Billiton was offered up to $6 million out of $10.7 million to install a special combustion unit that can burn low concentration mine ventilation air methane. This project is expected to abate 1 million tonnes of greenhouse gas emissions.

- *Endeavour & Munmorah Collieries in NSW* — Powercoal was offered up to $15 million out of $26 million to link the air intake of Vales Point power station to the ventilation system of the two mines. This project is expected to abate 4.4 million tonnes of greenhouse gas emissions.

- *Bellambi Mine in NSW* — Envirogen was offered up to $9 million out of $16 million to install gas engine generators at the mine to use methane gas drained in advance of mining. This project is expected to abate 1.8 million tonnes of greenhouse gas emissions.

- *German Creek Waste Gas Power Project* — Energy Developments Limited was offered about $11million out of $30 million to install and operate four x 3 MW gas turbines at Grasstree Colliery in central Queensland. This project is expected to abate 2.4 million tonnes of greenhouse gas emissions.

- *Telba Mine in NSW & North Goonyella Mine in central Queensland* — Evirongen was offered $13 million to install 10 gas engines at each of the two mine sites to generate electricity using waste mine gas as fuel.

CMM Projects in UK

The Association of Coal Mine Methane Operators represents 13 companies in the UK involved in the extraction and use of CMM from abandoned coalmines to generate electricity.

The waste gas has been a safety hazard to the community and a costly nuisance to the mining companies. Companies such as Coalgas took the contrary view and regarded the mine gas as a major energy resource located in the industrial heart of the UK. Country wide there are at least 150 mine vents or boreholes emitting mine gas to the atmosphere. Harnessing this gas as fuel could eliminate up to 150,000 tonnes per year of carbon dioxide equivalent greenhouse gas. Technologies have been developed to capture and commercialise the waste gas from abandoned mines and reduce its greenhouse effects by 95 percent.

The commercial viability of utilisation of CMM from abandoned mines in the UK has been proven since 1999 when Coalgas brought online three commercial gas extraction plants at Markham, Steely and Shirebrook under the Green Energy Parks scheme. Coalgas UK is also evaluating the viability of gas extraction from another 150 abandoned mine sites. The gas from Markham is sold to nearby industry as burner tip fuel and gas from Steely and Shirebrook is sold as fuel to a 6 MW power plant owned by Independent Energy UK and a 9 MW power plant owned by Alkane Energy UK. Octagon Energy has recently developed a 6 MW power plant at Hickleton using CMM and CBM as fuel.

CMM Projects in the USA

The Coalbed Methane Outreach Program is a voluntary program the goal of which is to reduce emissions from coal mining activities. The mission is to promote profitable recovery and use of CMM in the USA and worldwide. The program works cooperatively with the coal industry and related industries to help identify and implement methods of using CMM productively. The program has been providing technical assistance to the industry since its inception in 1994.

The total volume of CMM liberated in the USA in 2000 was 196 billion cubic feet (5,550 million m^3). The CMM emissions accounted for 10 percent of total US GHG emissions with underground mines being the largest source (142 billion cubic feet or 72 percent) and other sources including surface mines, abandoned mines and post-mining activities. About 30 percent of the underground mining CMM was emitted through the methane drainage system while 70 percent was emitted through the ventilation air system. US coalmines have recovered 86 percent of the drainage methane or the equivalent of removing 3.2 million cars from the road. The recovery of CMM from the ventilation air is yet to be utilised effectively.

Export Potential

As noted in Chapter 4, there is strong potential to export methane-reducing technologies using Waste Coal Mine Gas to countries such as the USA, China, Russia, Poland and other former Soviet Union countries. The Australian market for these technologies is estimated at up to 400MW (or $800 million in investment).[85] Australia represents under 5 percent of the world waste coal mine gas resource, meaning a potential world market of something like 15,000MW or $30 billion in investment (237 Mt/y of CO_2 equivalent GHG emissions worldwide).[86]

China has around 45 percent of the global waste mine gas resource. Recent resource assessments for coal bed methane carried out by the China Coal Information Institute and the US EPA in six coal mining areas in China show significant potential.[87]

85 SEDA expert estimate based on consultation with wide range of industry sources.

86 US EPA website www.epa.gov

87 http://www.coalinfo.net.cn/english.htm

Several Australian companies are developing new technologies to use low methane Mine Ventilation Air. These include:

- CSIRO (the Calorific Gas Turbine, and the Rotary Kiln);
- Energy Developments Ltd. (the Carburetted Gas Turbine); and
- BHP Billiton (the Megtech Vocsidiser).

These technologies are considered leading edge, with little competition internationally, and hence there is significant export potential if the market is developed to address niche demand. In addition, Australian companies such as Envirogen and Energy Developments are focusing on more traditional methods of power generation from the richer mine drainage gas and would also be able to win projects internationally if the market were developed.

In the move towards a carbon-constrained global economy, waste mine gas projects are of particular interest. The market views abatement certificates associated with methane abatement as low risk and high value. They are easily verifiable and there are few difficulties in establishing baselines.

7.7.4 Government Support Policies

Australia has policies and initiatives that have been introduced to encourage and promote the development of commercially feasible projects to utilise CMM. Such initiative sources include:

- *The Greenhouse Gas Abatement Program* — CMM projects described above have been awarded a $54 million portion of this funding to date.
- *Sustainable Energy Development Authority* — SEDA's $2.5 million Waste Coal Mine Gas Program aims to promote the capture and use of fugitive methane emissions from coal mine operations in NSW. The program offers 50 percent co-funding towards the feasibility studies of CMM projects and capital funding assistance for projects. The project must be technically viable, require only moderate financial assistance as a proportion of the total project cost and pursue all reasonable avenues to proceed beyond the feasibility study to fruition.
- *Queensland Energy Policy* — The Waste Mine Gas Abatement program is an initiative under the Queensland Energy Policy to encourage waste mine gas utilisation in the Queensland coal mining industry. The target is to reduce waste gas emissions from coalmines by 2.5 million tonnes of carbon dioxide equivalent per year for four years to a program total of 10 million tonnes by year 2012. The program has committed $1.5 million of funding.
- From January 2005, exported electricity generated from waste mine gas will be eligible under the new retail licence conditions requiring retailers to source 15 percent of the electricity sold in Queensland from gas and renewable energy.
- *Australian Coal Association* — The Australian Coal Industry Association is adopting international industry philosophies and goals such as "A Lower Emission Future for Coal" and "A zero Emission Future for Coal?" which include the utilisation of coal seam methane and prevention of its release to the atmosphere.

7.8 Bio-Diesel

7.8.1 Technology Description

Biodiesel is manufactured from vegetable oils and animal fats. Methanol or ethanol is added to the oils or fats in a heated reactor (in the presence of a catalyst) producing biodiesel and glycerol. The commonly used catalyst is either sodium hydroxide or potassium hydroxide. This process is called transesterification. The process can be carried out on a batch basis, or continuously. When the reaction is complete, the biodiesel is separated from the glycerol. The two products are immiscible and have different specific gravities (glycerol is the heavier) and can be separated by gravity. Centrifuges are normally used to speed the separation of these products.

The biodiesel and the glycerol are both valuable and need to be cleaned/refined for sale. The biodiesel contains methanol, remnant catalyst and other impurities. The methanol is more volatile than the biodiesel and should be removed. This is achieved primarily by distillation. The biodiesel is then washed to remove impurities; the water and remnant methanol mixture from the washing process is refined to recover the methanol.

The glycerol also contains methanol and remnant catalyst, and other impurities. As for the biodiesel, the methanol is removed by distillation and sent to the methanol recovery processes. Sulfuric acid is then added to the glycerol and agitated; the mixture splits into three phases comprising free fatty acids, glycerol and potassium sulfate salt. The glycerol and potassium sulfate are now saleable, the latter as a fertiliser, and the free fatty acids are sent to storage and reprocessing.

Properties of Biodiesel

Biodiesel has different properties depending on whether the biodiesel was manufactured from Canola oil or tallow. Biodiesel manufactured from Canola oil has a 5 percent (approximate) power disadvantage over diesel and tallow–based biodiesel has an 8 percent (approximate) power advantage over diesel. A 60/40 blend of tallow and Canola biodiesel delivers the same power as diesel.

Biodiesel turns to a gel above the freezing point of water. When temperatures fall below the gel point of the biodiesel, the fuel system must be heat traced to maintain the flow of fuel. Canola-based biodiesel has a gel point of around 1^{o} C; tallow-based biodiesel has a gel point of up to 14^{o} C. When blended 50/50 the gel point is approximately 4^{o} C, which makes it suitable for sale in winter along the seaboard of Australia.

The properties of biodiesel make it necessary to carefully consider the sourcing of feedstock and the blending of the different types of biodiesel, prior to distribution. Other properties of biodiesel are:

- greenhouse gas emissions are reduced by up to 90 percent;
- emissions of most harmful substances from engines running on biodiesel are lower than for normal diesel (the exception is NOx);
- biodiesel has enhanced lubricating properties;
- biodiesel has a much higher flash point than normal diesel and is therefore a safer product to handle; and

- if spilt, biodiesel biodegrades relatively quickly (breaks down to sugars and starches within weeks).

Fuel Costs

The capital cost of the plant varies from supplier to supplier, with the cost of a 100,000 tonne per year plant ranging from $4 million to $12 million. For a payback period of 12 months on full production, the cost would be 3.5 cents per litre to 14 cents per litre. Operating costs are low, of the order of 5 cents per litre (GHD calculation).

The main cost of production is the cost of supply of the feedstock and the methanol. For the various feedstock, this cost varies from 20 cents per litre to 90 cents per litre; the cost of methanol is of the order of 40 cents per litre, including transport.

7.8.2 Greenhouse Gas Abatement

Biodiesel is capable of reducing greenhouse emissions by an average of 72 percent and by up to 90 percent, depending on what feedstock is used and whether renewable fuels are used in the production process.[88]

Feedstock may be one or more of the following:

- vegetable oils: rapeseed, sunflower, canola, soybean, etc;
- high grade tallows (<1 percent FFA);
- low grade tallows (10 percent to 20 percent FFA);
- acid oils (by-product of margarine manufacture); and
- used cooking oils and fats.

Fossil fuels are normally used to provide the energy for the processing of feedstock. The energy used for the processing of vegetable oils is relatively low. On the other hand, rendering to produce tallows requires a relatively high energy input. Energy cost for transportation may also be high if the source of the feedstock is widespread.

Methanol is the other major input to the process. In Australia, methanol is primarily produced from methane from natural gas or crude oil. A small amount is produced from coal seam gas and an even smaller amount from biomass.

The choice of feedstock and the sourcing of methanol will differ from plant to plant and will be driven primarily by availability. Greenhouse emission reductions will therefore vary from plant to plant and, as noted, the anticipated reduction in greenhouse emissions will average 72 percent, but may be as high as 90 percent.

It should also be noted that there would be opportunities for energy cropping, that is, plants grown specifically for the production of oils to be used in the manufacture of biodiesel.

88 Australian Biodiesel Consultancy, www.biodiesel.net.au

7.8.3 Market Analysis

Domestic Market

The production from a 100,000 tonne per year biodiesel plant would account for only 0.5 percent of the Sydney/Newcastle market for diesel fuels. No excise is levied on biodiesel. Biodiesel is currently sold at a small premium, which reflects the willingness of the public to purchase 'green' fuels. This premium should be maintainable until the sales of biodiesel are significantly greater, say 5 to 10 percent of the diesel market. Thereafter, it is likely that a greater market share could only be obtained by a price differential.

International Market

Europe has relatively high excise duties for fuels for transportation. For biodiesel, there are exemptions in some countries, including Germany, France, Italy, Sweden, Austria and the Czech Republic.[89] The EU commission is aiming to develop a 5 percent market share for biofuels by the year 2005.

Distributed Generation

The ability for biodiesel to be utilised as a green replacement fuel for the numerous existing diesel standby generator plants throughout Australia warrants investigation. Currently, these power plants run during power failures and maintenance mode only. This is because of the cost, noise and adverse environmental effects of running the generators regularly. However, it is possible that this existing infrastructure could be used for peak lopping and cogeneration opportunities using biodiesel, without some of the environmental disadvantages associated with diesel.

Market Conclusion

As long as biodiesel is exempt from excise, the market for biodiesel appears to be good. At a discounted price to diesel, the market would be very promising.

7.8.4 Government Support Policies

Prior to the November 2001 Federal Election, the Deputy Prime Minister, John Anderson announced that no excise would be payable on biodiesel even when blended with other fuels. This has not been confirmed since the election, and is subject to the Commonwealth's full response to the Fuel Taxation Inquiry.

On 20 May 2002, the Environment Minister, Dr David Kemp, and the Agriculture Minister, Warren Truss, announced a $5 million, two-year study to address market barriers to the increased use of biofuels. The study will develop a broad strategy to increase biofuels production to 350 million litres per annum by 2010. Biofuels with commercial prospects in Australia include ethanol and biodiesel.

[89] Oelmuhle Leer Connermann GmbH & Co, www.biodiesel.de

8 MONASH Model Scenarios

This chapter outlines the results of general equilibrium economic modelling undertaken to assess the impact of various SEI policy scenarios. The modelling was undertaken for The Allen Consulting Group by the Centre of Policy Studies at Monash University using the Monash Multi-Region Forecasting-Green (MMRF-Green) model. MMRF-Green is a multi-sector dynamic computable general equilibrium model of the Australian economy. The model was enhanced for the purposes of this study to incorporate a range of renewable technologies as separate industry sectors in the model.

8.1 Summary of the Five Scenarios Modelled

For this study, a more detailed treatment of renewable generation technologies has been incorporated into the model. Instead of one generic renewable industry, there are now five separate industries, each producing electricity from a specific renewable source. The five sources are hydro, biomass, biogas, solar and wind.

For the purposes of the study, MMRF-Green has been used to model five scenarios:

- *Scenario One ¾ Baseline (no measures) Projection.* This scenario assumes that no government measures and policies or voluntary industry activities are specifically undertaken to reduce greenhouse gas emissions in response to global warming. It also does not take account of the energy market reform (EMR) that commenced in the early 1990s.

- *Scenario Two ¾ Baseline (with measures) Projection*. This scenario takes into account the impact of a range of supply and demand side measures put in place by governments aimed at reducing greenhouse gas emissions and of EMR. This scenario represents the ‘actual’ future economy as far it can currently be known.

- *Scenario Three ¾ Demand Management Measures*. This scenario assumes the successful implementation of a range of demand management activities in the industrial, commercial and residential sectors over a five-year period that, at full implementation, represents a reduction in electricity demand of 1070 MW. The DM measures and capacities are drawn from the SEDA Compendium and assumed to be fully implemented without the need for government financial assistance.

- *Scenario Four ¾ Expansion of the Mandatory Renewable Energy Target (MRET).* This scenario is based on a mandatory target of 19,000 GWh of additional renewable energy generation by 2010, which is broadly equivalent to the 5 percent renewable energy target recently proposed by some industry stakeholders.[90]

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90 The Australian EcoGeneration Association (AEA) and others have called for the expansion of MRET to 5 percent by 2010 by expanding the existing renewable energy target from 9500 GWh to 20,000 GWh. (AEA Press Release, *The Government’s Disappearing 2percent*, June 2001.

- S*cenario Five ¾ Policy Measures to Expand the NSW SEI*. This scenario models the impact of implementing additional measures (both supply and demand side) to grow the SEI in NSW. To simulate the impact of these measures, the model incorporates a fund that is used to promote investment in renewable energy generation and demand management.

8.2 Scenario One ¾ Baseline (no measures) Projection

In forecasting with MMRF-Green, a large amount of information from specialist external forecasting agencies is imposed on the model. Appendix B sets out the key assumptions used in the model. It is these assumptions that drive the results of the Baseline (no measures) Projection, in particular, the macroeconomic outcomes. Appendix C sets out the detailed results for the other key outputs of the model, such as:

- output by industry;
- greenhouse emissions; and
- electricity generation by fuel type.

8.2.1 Macroeconomic Indicators

As Scenario One is the pure baseline projection, the macroeconomic outcomes of this projection simply reflect the assumptions used in the model. These are detailed in Table B.1. The key outcomes/assumptions suggest that, over the period 1999 to 2020:

- NSW is projected to experience average annual growth in real Gross State Product (GSP) of 2.9 percent;
- real private consumption in NSW is projected to grow by an average of 2.8 percent per annum;
- real investment in NSW is projected to grow by an average of 3.1 percent per annum;
- NSW export volumes are projected to grow by 5.5 percent per annum on average, slightly more than average annual import volumes of 5.2 percent;
- aggregate employment in NSW is projected to grow by 1.1 percent per annum; and
- inflation in NSW is forecast to average 2.1 percent per annum.

8.2.2 Industry Output

Table C.1 in Appendix C sets out detailed industry output results under Scenario One. Following is a summary of the key results for NSW.

Non-electricity Industries

Communication services is projected to be the fastest growing industry in NSW (average rate of growth of 7.8 percent per annum). This reflects the assumption that changes in technology through the projection period will strongly favour intermediate usage of these services and that rapid productivity growth will reduce their price relative to consumer prices in general. Similar factors explain the relatively strong growth forecast for *Financial and business services*.

Other industries with relatively strong growth prospects in NSW include *Air passenger transportation, other transport services* and *other metal products*. These industries participate heavily in the strong growth forecast for international tourism and manufactured exports. In addition, changes in technology are assumed to favour intermediate usage of *other metal products*.

Forecasts for *Agriculture*, the mining industries, *Petroleum products* and *Alumina and aluminium* are, in the main, based on extrapolations of the current views of ABARE. The prospects for *Black coal* in NSW reflect a mixture of assumed export growth and projected growth in demand for local electricity generation. Local electricity demand is projected to increase at a slower rate than exports, reflecting, in part, the assumption of improved efficiencies in domestic generation. Most of the remaining industries have close to average growth prospects in NSW (ie, 2.9 percent).

Electricity Industries

Forecast growth of *Electricity supply* lags behind forecast GSP growth in NSW (and in all other regions). NSW electricity supply is forecast to grow at an average annual rate of 2.2 percent, 0.7 percentage points less than the average growth rate of the NSW economy.

The forecast below-average growth in electricity supply is explained by the interaction of three forces:

- weak growth in household demand due to a low-income elasticity for electricity;
- the assumption that there is no change in the efficiency with which industries use electricity and negligible change in consumer tastes. This means that technological and taste changes have little direct influence on the industry's growth prospects; and
- strong growth in all-factor productivity, which makes electricity cheaper and encourages favourable substitution effects in end-use demand. This third force offsets, but not completely, the first.

Of the generators, the fastest growing in NSW is forecast to be *Electricity generation — gas*. This reflects, in the main, announced and planned construction of new plants. Strong growth in gas-fired electricity capacity lowers the price of gas-fired electricity relative to coal-fired electricity. This restricts the growth prospects of coal-fired generation. Growth in renewable generation is weak, largely by assumption. We assume that, in the absence of any measures, there will be no growth in biogas, solar and wind generation, while a low growth rate is assumed for hydro generation.

8.2.3 Projections for CO_2-e Emissions by Major Source Category

Total greenhouse emissions in NSW are projected to grow at an average annual rate of 1.5 percent between 1999 and 2020. This is 1.3 percentage points less than the projected GSP growth rate. The main reasons why growth in aggregate emissions is forecast to be less than GSP growth are:

- a forecast growth rate for agriculture (a major contributor), which is less than the forecast growth rate for real GSP;[91]
- the shift towards natural gas and away from coal for electric power generation;
- improvements in electricity-supply efficiency; and
- faster-than-average growth of the service sectors, which are below average greenhouse gas emitters.

In 2020, the NSW total for all emissions (excluding land clearing) is projected to be 198 Mt. This compares with 146 Mt in 1999 and 171 Mt in 2010.

The energy sector shows the slowest growth in emissions in NSW with average growth of 1.2 percent per annum. Within the energy sector, emissions from fuel combustion are forecast to grow at an average annual rate of 1.2 percent, while fugitive emissions are forecast to grow at an annual rate of 2.1 percent. Growth in emissions from fuel combustion reflects, in the main, growth in emissions from electricity generation. A combination of increased fuel efficiency in generation, slow growth in electricity supply and a trend throughout the forecast period towards relatively clean gas-fired electricity explain the weak growth in electricity emissions.

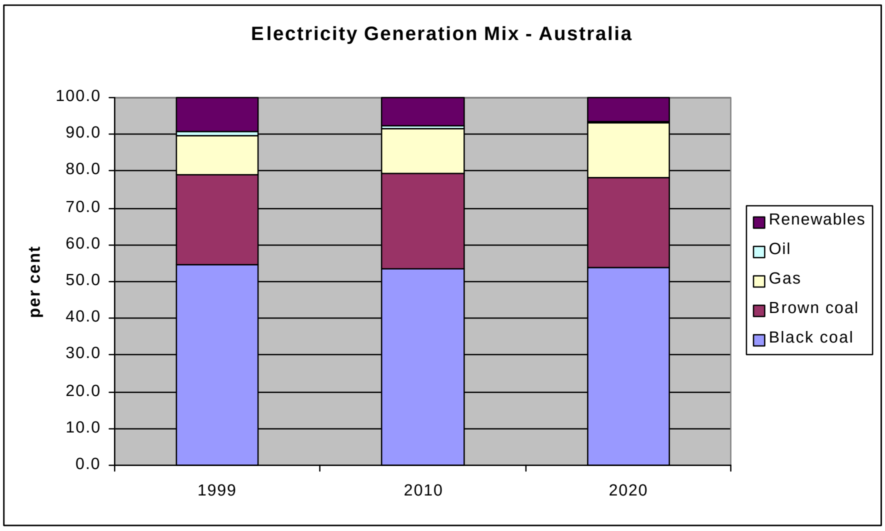
8.2.4 Projections for Electricity Generation by Fuel

Electricity generation in NSW will increase from 268.4 PJ in 1999 to 411.0 PJ in 2020, implying an average annual growth rate of 2.1 percent. Generation from black coal is forecast to grow at an average annual rate of 2.1 percent, while gas generation is forecast to grow by 4.2 percent per year.

A notable feature of the forecasts is the declining share of renewable generation across the country. Figure 8.1 show that renewable energy contributed just over 9 percent of total generation in Australia in 1999. According to the Scenario One projections, this share will fall to 7.6 percent in 2010 and to 6.4 percent in 2020. Most of this decline is absorbed by additional gas generation — gas's share of total electricity generation is forecast to increase from 10.7 percent in 1999 to 14.6 percent in 2020.

91 Our projection for growth in agricultural emissions is in line with our projection for growth in agricultural output.

Figure 8.1: Electricity Generation Mix — Australia



Source: MMRF-Green Modelling Results

A similar pattern of renewable decline is forecast for NSW. In 1999, the renewable share in total NSW generation was 10.1 percent. According to the Scenario One projections, this share will fall to 8.1 percent in 2010 and to 6.8 percent in 2020. Again, the change in generation mix is forecast to favour gas, with gas's share in total NSW generation forecast to rise from 2.6 percent in 1999 to 3.8 percent in 2020.

8.3 Scenario Two ¾ Baseline (with measures) Projection

8.3.1 Scenario Two: Assumptions and Shocks

Appendix D sets out the methodology and other assumptions used for the Baseline (with measures) Projection. For the purposes of this study, the key changes relate to the greenhouse emissions-reducing measures incorporated into the model. With these measures taken on board, this scenario best represents what the Australian economy is expected to look like in the future, having responded to the key policies and other measures being undertaken by governments that will impact on greenhouse emissions and energy industries, in particular, the renewable energy sector. The specific measures incorporated into this (and subsequent) scenarios include:

- Supply-side
  - energy market reform after 1999;
  - Queensland's cleaner energy strategy;
  - generator efficiency standards;

  – the Mandatory Renewable Energy Targets (MRET) and extensions to greenpower;
  – the Greenhouse Gas Abatement Program (GGAP) and the greenhouse-friendly certification program;
- Demand-side
  – the Greenhouse Challenge Program (GCP);
  – energy efficiency standards for residential and commercial buildings;
  – energy performance codes and standards for domestic appliances and commercial and industrial equipment; and
  – the Energy Efficiency Best Practice Program.

8.3.2 Scenario Two: Results

Detailed information on the results of the Baseline (with measures) Projection is set out in Appendix E. A summary of the key highlights as they related to NSW follows.

Macroeconomic Impact

The policy measures would have a mild impact on NSW macroeconomic variables. The measures reduce real GSP in an average year by 0.05 percent, which is equivalent to a reduction of about $142 million. Most of the decline is due to one measure — MRET. The other measures together increase real GSP, especially the productivity improvements associated with EMR. The MRET has a negative impact because it increases costs through forced adoption of more expensive renewable generation at the expense of cheaper fossil-fuel alternatives.

In the average year, NSW employment is 0.04 percent above its baseline (no measures) level, while capital is 0.04 percent below. The 0.04 percent increase in employment is equivalent to around 1,400 additional full and part-time jobs. The increased employment puts upward pressure on the real wage rate. In an average year, the real wage rate in NSW is 0.09 percent above its no-measures level.

On the expenditure side, in the average year, real private consumption in NSW falls by less than real GSP, but real investment falls by considerably more than real GSP. The decline in investment reflects, in the main, falls in investment in fossil-fuel generating industries and in fossil-fuel mining industries. These falls more than offset increased investment in renewable generation. Overall, real gross state expenditure falls by more than real GSP, implying an improvement in the balance between aggregate export and import volumes. In the average year, the aggregate volume of international exports from NSW is 0.09 percent above its no-measures value and the aggregate volume of international imports into NSW is 0.1 percent below.

Finally, it is of interest to note that the measures are projected to have a more than proportional negative impact on the NSW economy. For example, in the typical year national real GDP is 0.02 percent below its base case level, while NSW real GSP is 0.05 percent below. NSW is harmed relative to the rest of Australia because the share of industries that suffer decline as a result of the measures (ie, mainly the fossil-fuel generating industries and the electricity supply industry) is larger in NSW than in the rest of Australia.

Output and Employment by Industry

The measures significantly alter the industrial structure of the national and state economies. In terms of percentage deviations, in the average year, the industries in NSW that suffer the greatest declines are:

- *electricity — gas* (down 12.6 percent);
- *electricity — black coal* (down 9.4 percent);
- *electricity — supply* (down 8.3 percent) and
- *black coal* (down 0.7 percent).

Offsetting these declines are expansions in renewable generating industries:

- *electricity — wind* (up 293 percent);
- *electricity — biomass* (up 282 percent);
- *electricity — biogas* (up 282 percent) and
- *electricity — solar* (up 74 percent).

Not included in the list of industries that are expected to achieve significant gains in output is *electricity — hydro*. The reason is that hydro capacity is tightly constrained by a lack of additional water resources. The projections assume that hydro generation in NSW can expand, but by no more than 6 percent of its base case level.

Changes in production of other industries in NSW are much more moderate than those for the electricity and mining industries. Most of the consumption-oriented services industries are projected to experience small increases in output as a result of the measures. This is due to the effects of shifts in consumer tastes away from energy products (electricity and gas). Good examples of consumption-oriented industries that benefit are *dwelling ownership* and *private motor vehicle ownership.*

What does this imply for jobs? As noted, in an average year, the number of jobs in NSW is projected to increase by around 1,400 due to the measures. Around 500 new jobs are created in the renewable generating industries. Elsewhere, the largest job gains are projected to be in industries that are not directly affected by the measures, notably *Public Services*, *Financial and Business Services*, and *Trade and Hotels*. These are the big employers in the economy, and even though the percentage changes in their employment levels are relatively small, the absolute changes are relatively large. Some industries lose employment as a result of the measures. The industry that loses the most jobs is the construction industry with around 700 jobs shed.

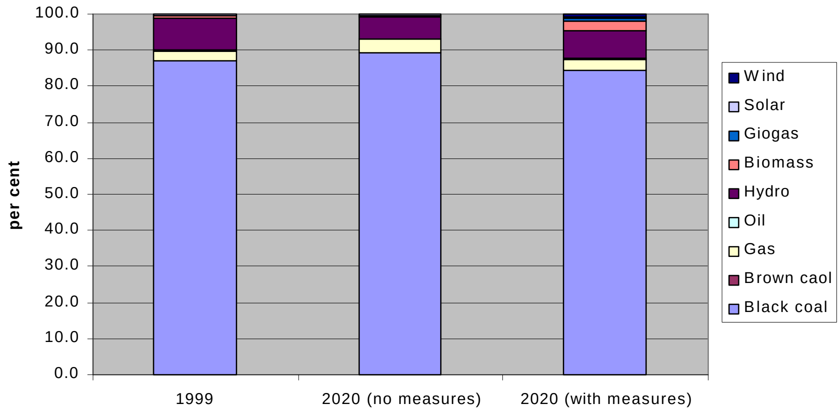
Greenhouse Gas Emissions

Greenhouse emissions in NSW are projected to fall by 7.8 percent in 2020 as a result of the measures. This is equivalent to a fall of 15.4 Mt. In 2010, emissions are down by 8.6 Mt. Nearly all of these falls can be attributed to reductions in emissions from electricity generation. Emissions from other sources are affected little by the introduction of the measures.

Electricity Generation by Fuel

As a result of the measures, total electricity generation in NSW in 2020 is projected to fall by 16.8 percent, equivalent to 75 PJ (nearly 21,000 GWh). The change in the mix of generators accompanying this fall is shown in the figure below. With the measures in place, the NSW share of renewable generation in total generation is projected to be 12.7 percent in 2020. This compares with 10.1 percent in 1999 and 6.7 percent projected for 2020 without the measures. In 2020, biomass generation in NSW is around 10 PJ (2,780 GWh) higher due to the measures. Biogas generation is up by 3.8 PJ (1,055 GWh), solar generation is up by 0.9 PJ (250 GWh) and wind generation is up by 0.2 PJ (56 GWh). Figure 8.2 shows how the mix of fuels changes between 1999 and 2020 under the Baseline (no measures) and Baseline (with measures) Projections.

Figure 8.2: Electricity Generation Mix With and Without Measures — NSW



Source: MMRF-Green Modelling Results

8.4 Scenario Three: Demand Management Measures

8.4.1 Scenario Three: Assumptions

Scenario Three models the impact of adopting a range of demand management measures in NSW. Although these measures are unlikely to occur without supportive policy initiatives, we have modelled their impact to determine their potential. In line with the project requirements, the measures and their potential capacity to reduce the required amount of electricity generation capacity are taken from SEDA's *Distributed Energy Solutions* compendium.

The compendium provides a summary assessment of costs, potential capacity and greenhouse emission reduction benefits of 35 generic sustainable energy technologies (including demand management, renewable energy and cogeneration) available in NSW (with a collective capacity of more than 5,000MW). Of these, six demand side measures (totalling 1,070MW) were used to illustrate some of the potential of this sector. However, there are other options that are not included in this scenario. To this extent, the estimated potential benefits of demand management may be considered conservative.

The demand management measures modelled (and the potential capacity reductions they imply) include:

1. commercial and industrial energy efficiency — includes measures undertaken by energy users to reduce consumption in areas such as motors and speed drives, control and insulation of process heating duties, lighting and ballasts, high voltage air conditioning systems, commercial hot water and office equipment (100 MW);

2. commercial and industrial standby generation — involves the use of standby generators in commercial and industrial premises used at times of peak network load or during National Electricity Market pool price peaks (100 MW);

3. commercial and industrial interruptibles — involves commercial and industrial customers shedding load or interrupting their loads during demand peaks (220 MW);

4. commercial natural gas cooling — the installation of gas rather than electric cooling in new commercial buildings and replacing electric cooling with gas in existing commercial buildings (200 MW);

5. residential energy efficiency — includes reductions in electricity consumption from improvements to residential lighting, space heating and cooling and efficient showerheads (150 MW); and

6. conversion of residential hot water from electricity to gas (300 MW).

Scenario Three assumes that the full potential capacity of the measures is realised and that implementation of the measures is phased in over a five-year period. It is assumed that implementation commences in year one and the benefits (and ongoing costs) begin to flow from year two and last for fifteen years generally reflecting the maximum life of capital involved (which varies from 10 to 15 years depending on the measure). For modelling purposes, it is assumed that the measures commence in 2005 (one commences in 2006 due to longer lead times) and run for sixteen years until 2020.

Information in the SEDA compendium was used to derive the data required to shock MMRF-Green to model the impact of the demand management measures. In particular:

- the capital cost of implementing the measures, which totals $724.4 million phased in over five years;

- the operating costs associated with the measures, which average $20 million per year;[92]

- energy savings, which rise to a maximum of around $2,000 GWh per annum;

92 To maintain for the fifteen-year life of capital that has a life of less than 15 years it is assumed that after capital has reached its maximum life, operating costs rise by 50 percent to keep the capital operating and that energy savings fall to 75 percent of their potential level.

- cost savings to electricity consumers, which rise to a maximum of $192 million per annum;[93] and

- network cost savings due to the reduction in the level of peak demand. This comes, in particular, from measures two and three that reduce demand peaks, but also the remaining measures (except residential hot water which is generally off-peak demand), which by reducing the overall base load, indirectly bring the peaks down. Leaving aside off-peak residential hot water, it is assumed that the level of peak demand is reduced by 70 percent of the potential capacity of the remaining measures (which amounts to 539 MW). Network cost savings rise to around $100 million per annum.

In line with the SEDA Compendium, the scenario is also based on an assumption that the demand management measures are 'no regrets', that is, they would not involve a net cost (over the medium term) to the companies and individuals that undertook them. In other words, the ongoing savings in electricity costs more than outweigh the up-front capital cost of the measures, within a commercially acceptable timeframe (a payback period of five years was used implying an internal rate of return of 20 percent after borrowing costs). Thus, in this scenario, financial incentives from the government are not required to encourage firms and individuals to invest in demand management, unlike the demand management component of Scenario Five (see below). However, non-financial incentives or measures (eg, mandatory requirements) are likely to be needed to encourage business and households to undertake the investment needed to reach the potential capacity levels identified in the SEDA Compendium.

Detailed information on the shocks used for the demand management scenario is set out in Appendix F.

8.4.2 Scenario Three: Results

Macroeconomic Impact

The cost savings and initial investment associated with the new demand management measures impart a macroeconomic benefit to NSW. In an average year between the commencement of the implementation of the DM measures and 2020,[94] real GSP in NSW is 0.17 percent higher than it otherwise would have been without the new demand management measures. This is equivalent to $510 million. All macro indicators for NSW are elevated by the new measures, with real consumption up by 0.16 percent in a typical year and real investment up by 0.03 percent.

The new measures increase employment in a typical year by 0.1 percent, with a peak gain occurring in 2010 when the full benefits of the cost savings are first felt. The typical-year percentage gain in employment is equivalent to 3,400 full and part time jobs.

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93 Cost savings are based on the assumption of a 20 percent internal net rate of return (ie, after taking borrowing costs into account if relevant). In other words, electricity users recoup the capital costs of demand management over a five-year period. While this a relatively high rate of return, as an average it is not unreasonable given information that the payback for some demand management measures can be as low as two years or less.

94 Averages are calculated for the sixteen years from 2005 to 2020, reflecting the fact that measures used to shock the model for scenarios Three, Four and Five commence operation in 2005.

The regional impacts of this scenario are broadly similar with increases in regional output varying between (0.12 and 0.13 percent) for most regions, with higher results for Sydney and the Hunter (0.15 percent) and Illawarra (0.16 percent). Employment exhibits a similar pattern with slightly stronger employment growth in Sydney, the Hunter and Illawarra compared to elsewhere in the State. Further detail on the regional impact of the scenario can be found in Appendix J.

Output and Employment by Industry

The main industries affected by the new demand management are the electricity generators and the electricity supply industry. Production of gas-fired electricity in a typical year falls by 1.74 percent, while production of coal-fired electricity falls by 0.33 percent. Electricity-supply is down by 0.37 percent in a typical year, though, through the period 2011 to 2020, the output in the industry is down 0.8 percent in a typical year.

Nearly all other industries in NSW gain as a result of the new measures. The industries projected to experience the largest gains in output are those that are most trade oriented or have strong connections to investment demand (eg, the cement industry). Most consumption-oriented industries also gain, reflecting both the expansion in aggregate consumption and the switch in consumer spending away from electricity.

In terms of employment, around 1,200 jobs are shed from the electricity supply industry in a typical year. This reflects the substantial reduction in electricity demand under this scenario as well as reductions in future augmentation of transmission and distribution systems to the significant network savings. However, this is more than offset by expansion elsewhere. The largest absolute increase in employment is in the *Trade services* industry.

Greenhouse Gas Emissions

Total greenhouse emissions in NSW are projected to fall by 0.1 percent in 2020 as a result of the new demand management measures. This reflects two offsetting forces: a reduction in emissions from fossil fuel generation and an increase in non-electricity emissions due to the expansion in general economic activity.

Electricity Generation by Fuel

The demand measures are designed to reduce electricity generation by around 7 PJ (around 2000 GWh). However, in 2020, total generation in NSW is down by only 3.6 PJ (1000 GWh). The difference reflects the increased demand for electricity arising from the general economic stimulation. Most of the fall in generation is borne by coal generators. Overall, the new measures do not significantly alter the NSW share of renewable generation, which remains at 12.7 percent in 2020.

8.5 Scenario Four: Expanded MRET

8.5.1 Scenario Four: Assumptions

Scenario Four builds on Scenario Three and models the impact of extending MRET from the present target of an additional 9,500 GWh (32.2 PJ) in renewable electricity generation by 2010 to 19,000 GWh. This is broadly equivalent to the adoption of a

5 percent renewables target as opposed to the 2 percent target on which the actual target of 9,500 GWh was originally based.

The extended MRET begins in 2005 and ends ten years later in 2014. It requires wholesale purchasers of electricity to proportionately contribute towards the generation of an additional (relative to levels in the Baseline (with measures) Scenario) 9,500 GWh (or 32.2 PJ) of renewable energy by 2014.

8.5.2 Scenario Four: Results

Detailed information on the results of the extended MRET scenario is set out in Appendix G. A summary of the key highlights as they relate to NSW is set out below. The results compare the Extended MRET Scenario with the Baseline (with measures) Scenario (Scenario Two).

Macroeconomic Impacts

In isolation, extending the MRET would have a negative impact on the Australian and state economy. This reflects the cost of using electricity generated from higher priced renewable sources instead of fossil fuels. The average cost of fossil-fuel generation in NSW is about $9 million/PJ (3.2 c/KWh).[95] On the other hand, the average cost of renewable generation (ignoring hydro) is about $15 million/PJ (5.4 c/KWh).[96] In 2020, the extended MRET will reduce fossil-fuel generation in NSW by 4.7 PJ (1,100 GWh) and increase renewable generation by 9.6 PJ (2,700 GWh).

The projections show that MRET is a costly measure in terms of its impact on the main macroeconomic variables. It is costly because it forces the adoption of more expensive renewable generation at the expense of cheaper fossil-fuel alternatives. In NSW, the extended MRET reduces real GSP by 0.06 percent in a typical year and employment by 0.02 percent.[97] These falls are equivalent to an annual reduction in economic output of $162 million and 700 full and part-time jobs (although included in this net result is an increase of 1,640 jobs within the renewable energy sector).

In 2020, the extended MRET will reduce fossil-fuel generation in NSW by 14 PJ (3,900 GWh) and increase renewable generation by 15 PJ (nearly 4,200 GWh). Applying the unit cost estimates to these changes in generation suggests that the extended MRET has a direct cost impact on the NSW economy in 2020 of around $100 million. In that year, real GSP is $240 million below its level in Scenario Two. Changes in factor employment accounts for most of the difference between the direct cost impact and the eventual GSP loss.

The overall negative economic impact of extending MRET is reflected in generally negative impacts on output and employment on a regional basis. The exceptions to this are regions that have resources related to particular renewable technologies (eg, regional areas generally where biomass and wind resources are located). These areas experience

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95 ABARE, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, Canberra, 2001, p.17.

96 This ABARE estimate is reasonably generous given other estimates of the generation costs of renewables reported elsewhere in this report. Although, it is noted that the ABARE estimate is based on new (ie, latest technology) plant and may not reflect the cost of existing renewable energy sources.

97 Based on an average over the period 2005 to 2020.

smaller reductions in output (and in a few cases, increases in output) than areas such as Sydney, the Hunter and the central and far west. Further detail on the regional impact of the scenario can be found in Appendix J.

Output and Employment by Industry

The extended MRET achieves its goal with minimum disruption to industries outside of the electricity sector. In the average year, NSW renewable generation (other than hydro) is elevated above its level in Scenario Two by around 50 percent. Black coal generation is down 3.7 percent and gas generation is down 2.1 percent. Electricity supply declines slightly, reflecting the increase in average generator cost.

In terms of the NSW renewable industry sector (excluding hydro), in 2020, an extended MRET would increase the annual output of the:

- biomass industry by 71 percent and 1,130 jobs;
- biogas industry by 71 percent and 470 jobs;
- solar industry by 26 percent and 20 jobs; and
- wind industry by 109 percent and 20 jobs.[98]

In terms of comparing the results of this study with other studies on the employment impact of increased investment in renewable technologies, it is important to note that the jobs reported above relate to direct jobs in those sectors. Additional indirect jobs, in areas such as manufacturing, construction and maintenance, appear against those sectors of the economy in the MMRF-Green model. Thus, while created by the expansion of activity in (for example) the wind sector, these indirect jobs are not reported as wind industry jobs. This approach differs from other partial analyses of expanding renewable generation where all the jobs created, regardless of which industry sector they are in, are attributed to being 'wind industry' jobs.

Greenhouse Gas Emissions

Total greenhouse emissions in NSW are projected to fall by 1.2 percent in 2020 as a result of the extended MRET. This is equivalent to a fall of 2.3 Mt. In 2010, emissions are down by 1.1 Mt.

Electricity Generation by Fuel

With an extended MRET in place, the share of renewable generation in total generation in NSW in 2020 is projected to be 16.5 percent. This compares with 12.7 percent with all measures except the extended MRET in place (Scenario Two) and 6.8 percent without any measures (Scenario One).

98 The small number of jobs reflects the very small base against which the increase in NSW wind generation takes place compared to some other states and the relatively low job intensity of wind compared to, for example, the biomass industry, which also employs people in the resource sector of the industry.

8.6 Scenario Five ¾ NSW Sustainable Energy Industry Development Fund

8.6.1 Scenario Five: Assumptions

Scenario Five models the impact of implementing additional measures (both supply and demand side) to grow the SEI in NSW. To simulate the impact of these measures, the model incorporates increased investment in renewable energy generation and demand management of $75 million per annum for five years. This total investment of $375 million is financed 50:50 by the public and private sectors. It is assumed that the private sector investment is leveraged by the establishment of an SEI Development Fund of $37.5 million per year that operates for five years.

However, the establishment of a fund is but one way of encouraging the SEI and leveraging additional private investment. Alternatively, measures to support the industry could take a number of forms including a range of policies, programs and regulatory measures designed to promote investment in sustainable supply and energy efficiency/demand management, for example, expansion of SEDA's Energy Smart Business (ESB) program that has been successful at leveraging private investment in demand management at a rate of around $10 in private investment for every $1 in ESB program funding.

For the purposes of modelling this scenario, it is assumed that the government funding and private investment is split two-thirds in favour of increased demand management and one-third for increased investment in renewable energy. For the demand management measures, the estimates for operating costs, electricity cost savings and network cost savings are in proportion to the costs and savings used for the DM measures in Scenario Three.

The full range of assumptions used to model the fund is set out in Table 8.1.

Table 8.1: Exogenous Inputs Used to Model the Effects of a NSW SEI Development Fund ($m)

	2005	2006	2007	2008	2009	2010	2011	2012
Capital investment in DM	50.0	50.0	50.0	50.0	50.0	0.0	0.0	0.0
Investment in renewable generation	25.0	25.0	25.0	25.0	25.0	0.0	0.0	0.0
Operating costs (DM only)	1.6	3.2	4.8	6.4	8.0	8.0	8.0	8.0
Electricity cost saving (DM only)	0.0	11.2	24.3	37.5	38.0	64.5	64.5	64.5
Network cost saving (DM only)	0.0	6.8	13.5	20.3	27.1	33.8	33.8	33.8
General government expenditure	-30.0	-30.0	-30.0	-30.0	-30.0	0.0	0.0	0.0
Government charges	7.5	7.5	7.5	7.5	7.5	0.0	0.0	0.0
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Capital investment in DM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Investment in renewable generation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Operating costs (DM only)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Electricity cost saving (DM only)	64.5	64.5	64.5	64.5	64.5	64.5	64.5	64.5
Network cost saving (DM only)	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8
General government expenditure	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Government charges	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: The Allen Consulting Group

For modelling purposes, the scenario assumes that the fund is paid for by an across the board reduction in government expenditure (of $30 million per annum) and an increase in taxation (of $7.5 million per annum) for the five years in which the fund operates. It is also assumed that the funding leverages an equal investment by the private sector.

The additional renewable investment is spread proportionately across all renewable-generator types other than hydro. It is assumed that when the additional renewable investment becomes operational, it replaces renewable generation in other states.[99]

8.6.2 Scenario Five: Results

The following results are in terms of the deviation of the impact of Scenario Five from the base case for this scenario, which is the cumulative impact of scenarios three and four. The cumulative impact of these scenarios, which nets out the results of each, gives the fuller picture of what the NSW economy and the SEI industry could look like if all the measures in the three 'policy change' scenarios (ie, scenarios three, four and five) were put in place.[100]

The cumulative nature of the scenarios is an important part of the renewable industry story in Scenario Five because the investment in renewables in this scenario is aimed in part at capturing the increased investment in the industry as a result of an extended MRET that would have gone to other states because of their comparative advantages in particular renewable industries (eg, due to good wind resources in Victoria and South Australia and biomass resources in Queensland). Further details of the results for Scenario Five are at Appendix I.

Macroeconomic Impact

The macro-level effects are similar in sign to the effects of the demand measures considered in Scenario Three. Activity is stimulated generally by the investment that the fund helps to finance. In the average year between 2005 and 2020:

- investment in NSW is up 0.06 percent (nearly $46 million);
- real consumption is up 0.06 percent (nearly $100 million); and
- real GSP is also up 0.6 percent (or $170 million).

For Australia as a whole, GDP is only $75 million higher in a typical year reflecting the fact that the fund draws activity away from other jurisdictions. This reflects a fall in activity of $96 million per annum in other states and territories.

Over the period 2005 to 2020, employment increases 0.04 percent, which is equivalent to around 1,400 additional jobs in an average year. Reflecting the way the fund captures

99 This is consistent with the modelling assumptions that there are contemporaneous national-level measures (ie, the MRET and the extended MRET) that effectively constrain total renewable generation through the projection period. In this context, any state initiative to encourage renewable generation is accompanied by reduced renewable generation elsewhere.

100 Scenario Two is not considered a policy change scenario because the measures it incorporates are existing government policy and, in many cases, are already implemented.

economic activity from other jurisdictions, jobs in the rest of Australia fall by an equivalent amount.

There is little difference in the regional impact of Scenario Five. All regions receive an employment increase on average of between 0.03 and 0.05 percentage compared to the baseline scenario (ie, scenarios two, three and four) with those regions that are likely to be the location of wind or biomass generation at the higher end. Further detail on the regional impact of the scenario can be found in Appendix J.

Output and Employment by Industry

Additional measures to encourage the SEI as modelled in this scenario generates additional renewable generation in NSW at the expense of renewable generation elsewhere. In the average year, NSW renewable generation (other than hydro) is elevated above its no-fund level by around 9 percent. Black coal generation is down 0.5 percent and gas generation is down 1.2 percent. Electricity supply declines slightly, reflecting, in the main, the new demand management measures. The financing requirement of the fund depresses general government expenditure in the years 2005 to 2009. Thus, the production response in the government-related industries during this period is subdued.

Greenhouse Gas Emissions

Table 9.7 shows that the total of emissions in NSW are projected to fall by 0.2 percent in 2020 as a result of the new investments. This is equivalent to a fall of 0.4 Mt. In 2010, emissions are down by 0.2 Mt.

Electricity Generation by Fuel

Under this scenario, the share of renewable generation in total generation in NSW in 2020 rises relatively modestly. This reflects the increase in renewable generation and the decrease in electricity supply generally. Compared to the already significant increases in renewable generation as a result of the extended MRET scenario, in a typical year between 2005 and 2020, industry output is:

- 10 percent higher for biomass;
- 11 percent higher for biogas;
- 12 percent higher for solar; and
- 16 percent higher for wind.

8.7 Cumulative Results: All Scenarios

Scenario Five is modelled against a scenario that includes the cumulative impact of Scenarios Two, Three and Four. Scenario Two is considered a ‘no policy change’ scenario because it represents existing government policy. To give a fuller picture of the potential impact of Scenario Five it is necessary to combine the results of Scenarios Three, Four and Five to give an overall outcome of the potential impact on the NSW economy and the electricity industry of all the policy change measures considered in this report.

The overall results are set out in Table 8.2. The table indicates that the overall impact of adopting all the measures modelled would, in an average year, increase NSW:

- GSP by 0.17 percent or around $500 million; and
- employment by 0.12 percent or about 4,100 full and part time jobs.

Table 8.2: Macroeconomic and Greenhouse Impacts ¾ Cumulative Results: Scenarios Three, Four and Five (average year between 2005 to 2020)

Indicator	Scenario Three	Scenario Four	Scenario Five	Overall Net Result
Gross State Product (percentage deviation)	0.17	–0.06	0.06	0.17
Gross State Product ($m)	510	–162	170	518
NSW Greenhouse Emissions in 2020 (Mt CO2-e)	–0.1	–2.3	–0.4	–2.8
Total NSW Employment (percentage deviation)	0.1	–0.02	0.04	0.12
Emp: Fossil Fuel Elec Generation in NSW (No)	–50	–180	-40	-270
Emp: Renewable Elec Generation in NSW (No)*	–20	1,140	190	1,310
Emp: Rest of Economy (No)	3,470	–1,660	1,250	3,060
Total Net Employment (No)	3,400	–700	1,400	4,100

* Figures relate to direct energy industry jobs, indirect jobs (eg, manufacturing, construction, trade services) are not included.

While Scenario Five was modelled against a base case that included the cumulative impacts of scenarios two, three and four, the broad macroeconomic impact of Scenario Five in terms of GSP and jobs would be broadly the same if Scenario Five was undertaken in the absence of the expanded DM and renewable activity in scenarios three and four. However, this is not true of the impact of Scenario Five on the particular sectors of the energy industry. For example, a 10 percent growth in the wind sector with Scenario Five modelled against Scenario Four would be off a much higher base (due to the wind industry expansion from a 5 percent MRET) than if Scenario Two had been used as the base case.

Table 8.3 sets out the overall impact of the three policy change scenarios on the electricity industry.

Table 8.3: Electricity Generation in NSW in 2020 ¾ Cumulative Results: Scenarios Three, Four and Five

Sector	Scenario Three	Scenario Four	Scenario Five	Overall Net Result
Percentage Deviation				
Black Coal	-0.9	-4.2	-0.9	-6.0
Brown Coal	0.0[a]	0.0	0.0	0.0
Gas	-2.8	-4.6	-0.9	-8.3
Liquid Fuel	0.0	0.0	0.0	0.0
Hydro	0.0	0.0	0.0	0.0
Biomass	-1.2	70.7	6.1	r
Biogas	-1.2	70.7	6.4	75.9
Solar	-0.4	26.2	9.2	35.0
Wind	-0.2	108.9	8.0	116.7
Absolute Deviation (GWh)				
Black Coal	-805.62	-3694.74	-777.84	-5278.2
Brown Coal	0.0	0.0	0.0	0.0
Gas	-111.12	-194.46	-27.78	-333.36
Liquid Fuel	0.0	0.0	0.0	0.0
Hydro	0.0	0.0	0.0	0.0
Biomass	-55.56	2833.56	250.02	3028.02
Biogas	-27.78	1111.2	111.12	1194.54
Solar	0.0	111.12	27.78	138.9
Wind	0.0	111.12	0.0	111.12

Source: MMRF-Green Modelling Results

Note: Results are only reported to one decimal place. Thus a result of 0.0 will generally not mean no change but a change of less than 0.05.

Overall, generation of black coal and gas fall by around 6 and 8 percent respectively in an average year between 2005 and 2020. On the other hand, renewable technologies increase significantly, by 35 percent for solar, 75 percent for biogas and biomass and 117 percent for wind. In terms of capacity, biomass has the greatest potential in NSW followed by biogas.

9 Strategies to Encourage the NSW SEI

In this chapter we identify some key strategies that NSW could adopt to encourage development of the SEI sector, and to attract investment and jobs. We focus on three areas, selected for their impact across the sector. Firstly, development of an investment fund, much like the demand management focussed model supported by IPART, but also capable of investing in proprietary technologies and renewable energy generation. Secondly, we suggest some regulatory and information-enhancing measures. Finally, some suggestions for leveraging strategic partners are offered, including facilitation of key inputs into SEI sector development.

Strategy 1: SEI Development Fund

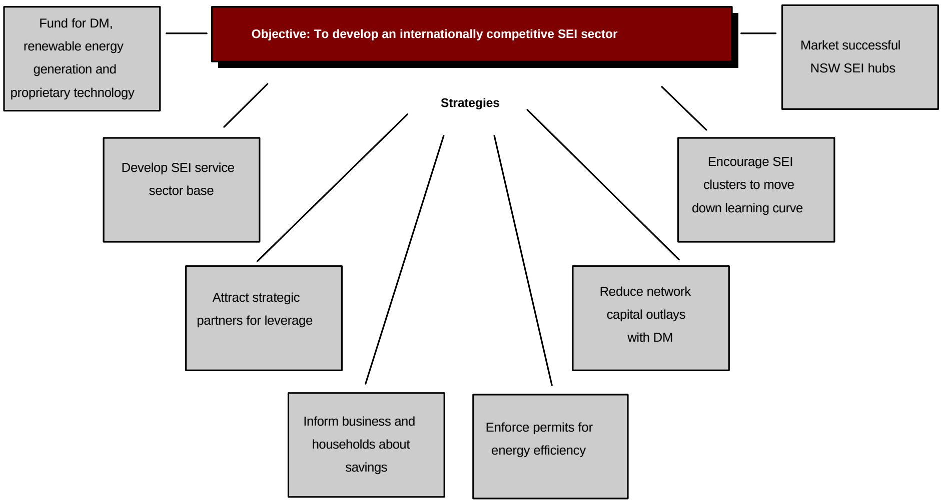
Strategy 2: Regulatory Measures

Strategy 3: Engaging Strategic Partners and Facilitating Inputs

9.1 The Objective is Competitiveness

To put highlighted strategies in perspective, Figure 9.1 provides a range of initiatives and actions that, together, have the potential to develop an internationally competitive SEI sector. Some require additional regulatory powers, and others call for managing capital outlays associated with energy demand. As a group, these initiatives can position NSW as a leading hub of SEI technology development and application. Each element of the framework is interconnected with other elements. For example, a fund capable of leveraging investment by the private sector will build strategic partnerships. But in order to deliver the kind of wide-scale activity required to utilise the capacity for DM in NSW, the embryonic SEI service sector (experts in retrofitting buildings, developing fuel switching strategies, or using metering to reduce demand) needs to be actively developed. Otherwise, a service bottleneck will prevent large-scale take-up of possible solutions. Similarly, without broad dissemination of the potential for energy and financial savings, businesses and households would be unlikely to participate.

Figure 9.1 — Objectives and Strategies



Source: The Allen Consulting Group

9.2 Strategy 1 — SEI Development Fund

IPART raised the idea of a demand management fund in the Interim Report to its demand management inquiry in NSW.[101] IPART's objective is to fund specific programs aimed at increasing energy efficiency and reducing demand. This would deepen the transformation of the DM market by increasing the level of activity and stimulating supply in bottleneck areas. This is a common approach in the US and the UK where public funds are provided to retailers for specific, approved programs that reduce demand. In NSW, these funds are currently given to SEDA but the level of resources is nowhere near the amount required to achieve the learning needed to build competitiveness for the SEI or substantially reduce electricity demand.

9.2.1 The Virtuous Cycle

IPART's focus is on achieving efficient energy savings and maximising capital management for the network. However the fund modelled in this study has a broader focus on creating investment and jobs in the SEI, which requires achieving a competitive advantage over other states. NSW has a window of opportunity in which to build a virtuous cycle for the SEI.

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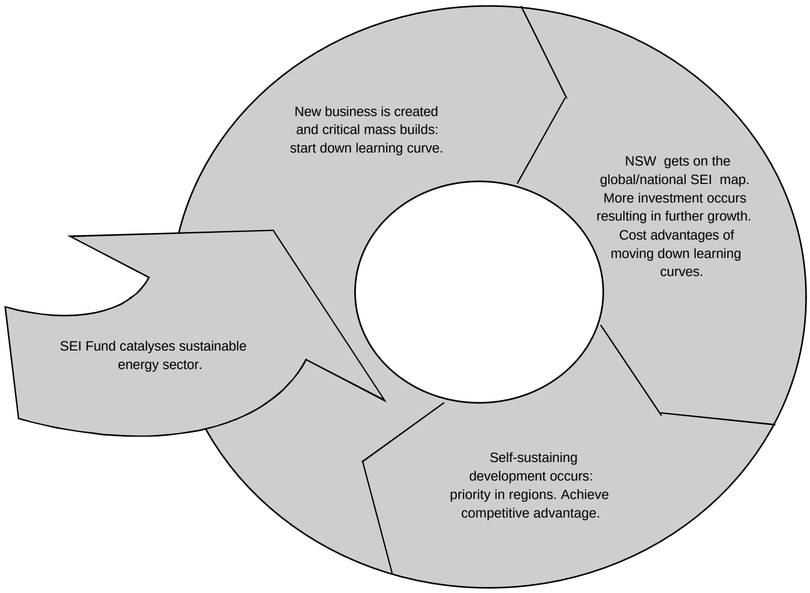
101 IPART, *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services*, April 2002, p. 23.

Figure 9.2 — The SEI Sector NSW: Building the Virtuous Cycle



Source: The Allen Consulting Group

9.2.2 Overseas Precedents

At the moment, SEDA administers a Sustainable Energy Fund that invests to commercialise promising renewable energy technologies. SEDA also funds demand management services through its Energy Smart Business program. But SEDA’s overall budget of around $10 million is dwarfed by the magnitude of public spending overseas on energy efficiency and renewable programs. There are various overseas precedents for funding environmental programs with public funds. In the US and the UK, modest charges on electricity consumers have been levied to provide funds for electricity retailers to deliver these types of programs. To put this in perspective, the US State of Illinois (with a population of 3.4 million) is spending A$215 million on energy efficiency (74 percent), renewable energy (19 percent) and low-income programs (7 percent) from a fund created through legislation. This is a typical US State funding mechanism as outlined in Table 9.1 below.

Table 9.1:

Summary Table of Public Benefit Programs and Electric Utility Restructuring (May 2002)

Arizona	In Dec96, the ACC ordered retail competition		**Details of SBC Funding**					**Renewables**	**Generation**
	beginning in Jan99 and completed by Jan03. Later		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	delayed to begin in 2001. ACC rule requires SBC for	**million $**	TBD	4.0	3.9	20.0	28.0	ACC rule calls for	Fuel mix and
	LI, EE and RE. Funding determined in indiv. utility	**mills/kWh**	TBD	0.14	0.13	0.67	0.94	0.2% by 2001, up to	emissions are
	cases. Also a separate charge for an "Environmental	**% rev.**	TBD	0.15	0.2	0.75	1.1	1.1% by 2007. Half	required by
	Portfolio Standard" (see RE). Also, EE may be shifted into RE.	**admin.**	TBD	utility	utility	utility		must be solar elec.	ACC rule.
California	In Sept96, AB1890 signed into law, with full retail access Apr98.		**Details of SBC Funding**					**Renewables**	**Generation**
	A 4-yr. SBC was created using a non-bypassable wires charge.		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	In Aug00 the SBC got 10-yr extension, with inflation adjustment.	**million $**	62.5	228.0	100.0	135.0	525+	None.	Yes. A "power content
	Table shows just the 4 large IOUs. Small IOUs and muni's are	**mills/kWh**	0.4	1.3	0.5	0.8	3.0		label" is required for
	also spending over $100 million/yr on pub ben. (New additional	**% rev.**	0.4	1.3	0.5	0.8	3.0		generation mix.
	$400 million for EE pledged by state also not included in table.)	**admin.**	CEC	Utility	CPUC	CEC			
Connecticut	In April 1998 Public Act 98-28 was signed into law.		**Details of SBC Funding**					**Renewables**	**Generation**
	Phases in retail access during 2000. It funds EE, RE,		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	and LI. RE ramps up over time, average is in table.	**million $**	in RE	87.0	8.7	22.0	117.7	Two tier, limits hydro	Included in bill with-
	Support for R&D is imbedded in the RE	**mills/kWh**	in RE	3.0	0.3	0.75	4.00	starting at 6% and	out specifics.
	programs. Funds are collected through a non-	**% rev.**	in RE	3.0	0.3	0.75	4.0	escalating to 13% by	
	bypassable wires charge.	**admin.**	EE &RE	collab.	DPUC	St Auth.		the year 2009.	
Delaware	Restructuring Act signed in March 1999. Has two		**Details of SBC Funding**					**Renewables**	**Generation**
	SBCs: 0.178 mills/kWh for EE "incentive" programs,		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	overseen by DE Economic Dev. Office, 0.095 mills/	**million $**		1.5	0.8	0.3	2.6	None.	Not required. Law
	kWh for LI bill asst. & EE, overseen by Dept. of Health	**mills/kWh**		0.18	0.1	0.03	0.3		says Commission
	& Soc. Services. An additional $250,000 from rates	**% rev.**		0.3	0.15	0.05	0.5		"may" promulgate
	is to go to customer education, esp. regarding RE.	**admin.**		state	state	state			rules.
District of	In May 2000 Congress passed restructuring bill for D.C. Includes		**Details of SBC Funding**					**Renewables**	**Generation**
Columbia	a "Reliable Energy Trust Fund". To be funded by a non-		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	bypassable charge of up to 0.8 mills/kWh. (After 4 years, can	**million $**		TBD	TBD	TBD	8.0	Commission Working	Disclosure of fuel mix
	increase to a maximum of 2.0 mills/kWh.) Covers EE, RE and LI.	**mills/kWh**		TBD	TBD	TBD	0.8	Group is examining the	is required. To be
	To be administered by the local District government. As of Oct.	**% rev.**		TBD	TBD	TBD	1.0	issue.	reported every 6 months.
	2001, charge is 0.21 mills with further allocation TBD.	**admin.**		City	City	City			
Illinois	In Dec97, PA 90-561 was signed. It provides funding		**Details of SBC Funding**					**Renewables**	**Generation**
	for EE, RE and LI (although EE and RE are at low		**R&D**	**EE**	**LI**	**RE**	**Total**	**Portfolio Standard**	**Disclosure**
	levels), using non-bypassable flat monthly charges on	**million $**		3.0	75.0	5.0	83.0	None.	All electricity retailers
	customer bills. ("mills/kWh" equiv. includes $ from gas	**mills/kWh**		0.03	0.6	0.04	0.7		would be required to
	& electric.) Also, one-time ComEd $250 million Clean	**% rev.**		0.04	0.8	0.05	0.9		disclose generation
	Energy Trust fund ok'd by legis. May 99 (not in table).	**admin.**		DCCA					mix and emissions.

TBD = to be decided
SBC funding amounts provided in the table are average annual funding levels.

Source: American Council for an Energy Efficient Economy. Accessed from www.aceee.org/briefs/mktabl.htm.

Broadly speaking, the fund modelled earlier in this report in Scenario 5 calls for a $1-for-$1 contribution from the private sector, with total funds of $75 million per annum. Public funding of $37.5 million per annum is leveraged by industry and household expenditure on approved and possibly accredited projects and technologies. For modelling purposes it was conservatively assumed that outlays were in the form of grants. Higher leverage (of up to 15 times based on experience in other areas of public policy) from the public investment could be achieved if low interest loans were made to businesses and households trying to leverage their own returns through a lower cost of capital.

The modelling analysis also assumed that of the $37.5 million public commitment, $25 million would be allocated towards DM activities and that this investment would be recouped after five years. The remaining $12.5 million would be available to assist renewable energy generation projects and/or to commercialise promising technologies and projects, so that they progress down the learning curve, driving costs down and building up experience.

SWERF is an integrated package of technologies for recycling and processing of municipal waste, turning the lower value parts of the waste stream into energy. SWERF was developed and is being commercialised by Energy Developments Ltd. SEDA provided $1m in assistance to EDL to help develop the gasifier technology. It is anticipated to have a lower capital cost than similar technologies coming from Europe/US, and so is more likely to find opportunities in developing countries.

9.2.3 Investment Styles

A range of possible investment styles is available to the fund, depending on the level of risk acceptable to the NSW Government. In addition to grants and low interest loans, direct equity investments are possible, as well as purchase of shares in intellectual property, joint ventures with renewable energy developers, and working capital support for emerging DM service specialists. To provide stability and continuity, we have assumed 5 years of funding, with a $1 for $1 contribution from public and private sectors. The 1:1 leverage ratio of public to private funds could be increased substantially if discounted debt or equity investments were encouraged — but to be conservative, it was assumed that public funds were spent in the form of matched grants to private initiatives.

9.2.4 Fund Performance Measurement

To ensure accountability and accurately measure economic and environmental contribution, the fund's results should be independently audited. This should occur independent of the NSW benchmark regime for retailers. As IPART notes:

> "Provided the energy efficiency achievements of its programs are not attributed to individual retailers, any inaccuracies in estimating their impact will accrue to all retailers collectively."[102]

9.2.5 Sources of Funds

There are several funding options ranging from a US-style public benefits type charge, which would be levied on consumers (designed so that it could not be bypassed), to using penalties collected from non-compliant licence-holders, to consolidated revenue.

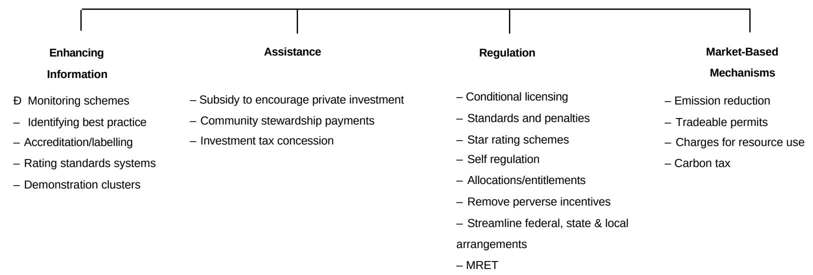
For purposes of modelling a fund under Scenario 5, the sourced funds were conservatively assumed to come from consolidated revenue (the analysis was conducted on the basis of fiscal neutrality based on a combination of tax increases and expenditure reductions), in the belief that this would give greater certainty that the specific amount of $37.5 million could be raised. This would give private sector investors a greater sense of certainty as well.

9.3 Regulatory and Market Based Instruments

Investment attraction through strategic funding is one of several instruments available to influence economic behaviour in NSW. Figure 9.3 outlines information enhancing options, strategies for assistance, regulatory alternatives, and market-based instruments for policy intervention.

102 IPART, *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services,* April 2002, p. 26.

Figure 9.3 — Instruments to Influence Economic Behaviour



Source: The Allen Consulting Group

Of the options available, in addition to the investment fund, it is recommend that government give consideration to the following measures:

1. adopt a Victorian EPA-style system of enforceable permits and licences which specify greenhouse reducing energy efficiency programs for medium and large-scale industry;

2. consider upgrading the mandatory star rating system for new homes and buildings in NSW;

3. encourage an expansion of training and accreditation programs for demand management service providers (companies specialising in developing and implementing strategies for major energy efficiency and peak clipping projects); and

4. introduce community stewardship payments to encourage local communities to buy into the broader benefits available from renewable energy generation.

9.4 Leveraging Strategic Partners

To achieve the vision of full participation in DM and renewable energy commercialisation clusters, NSW will require strategic partnerships with major national or international companies, research and development organisations and investors. Local communities will need to be engaged in a constructive manner, with an emphasis on sharing the tangible and intangible benefits and risks of SEI entrepreneurship.

The need to attract strategic partners is not about simply enticing large national or global companies to establish a presence in NSW as a generator of local employment opportunities, although the benefit of extra NSW jobs is welcome.

Strategic partners offer far greater opportunities beyond local jobs, including:

- the inflow of resources, including physical and knowledge capital;

- improvements in the technological capabilities of local companies and individuals as a result of greater exposure to world-best practice;

- the ability to place local companies within a strategic partner’s supply chain;

- the ability to have local products and services promoted globally through a strategic player's global networks; and
- the ability to help place NSW on the global SEI 'map'.

A key requirement of developing constructive strategic partnerships with major entities is to ensure that the potential partner is closely aligned with the vision of NSW's sustainable energy future. The focus should therefore be on:

- *cooperative* companies that sympathise and can contribute toward the broader goals of NSW communities — in particular, in regional NSW where renewable generation projects are likely to occur;
- *innovative* companies that are at the leading edge of technological advancements;
- *permeable* companies that offer multiple entry points to local industry into their value chain; and
- *collaborative* companies that are willing to engage the education sectors in R&D and skills development.

The twin purpose of this strategy is that working with a global/major national partner exposes NSW to the leading edge in technology development and at the same time exposes the rest of Australia and the world to the products and services available in NSW.

9.4.1 Growing Partnerships, Networks and Clusters

A true sense of partnership and collaboration from all sectors of the community is needed in those areas where SEI clusters naturally form. Government, industry, education and the wider community must combine their strengths to commit to the common vision of NSW's full participation in the sustainable economy.

Government, industry and the education sector should show a greater preparedness to embark on joint initiatives and develop a consensual and mutually reinforcing approach to laying the fundamentals for growth in the SEI. To achieve this strategy, human networks will be important. Part of SEDA's role (and other NSW SEI leadership organisations such as the EPA, and the Ministry of Energy) is to foster SEI networks in order to spread information about opportunities, risks, new developments, and potential developments.

An additional source of collaboration between NSW businesses is in the development of clusters. The beneficial effect of clusters in industry development has been well documented. Consequently, the encouragement of cluster formation has been a cornerstone of government industry policies across almost all industries around the world.

The role of clusters in the development of the information economy, for example, has been pivotal towards industry development in that sector nationally. In his presentation to the Tasmania 2010 Forum, TECC CEO John McCann spoke of the role of clusters in fostering regional economic development — see Box 9.1.

Box 9.1: Cluster Development: A Tasmanian View

There is a large amount of research to indicate the important role that clusters play in r gional economic development. Recent research undertaken by the Milken Institute concludes hat high tech clusters are driving growth in the US, and that areas without these clusters are bei g left behind. Worldwide, there are a vast number of examples of clusters at various stages development. While we can look at established clusters such as Silicon Valley, we can lso learn from areas working to initiate information industry clusters. For example, Connect ut in the US is currently working to establish a telecommunications and information industry luster with the objectives of:

- improving the State's long-term competitive position;
- paving the road to the State's economic prosperity; and
- improving the quality of life for all residents for years to come and draw particular a ention to the need for:
- addressing current weaknesses and risks;
- increasing productivity and innovation; and
- strong, visionary leadership and commitment.

Achieving collaboration between businesses, educational institutions, government and e workforce — "moving in concert to sharply improve the business environment".

Source: John McCann, *2010 Forum Presentation*, October 1999, p.9.

In many cases, clusters are specifically tied to a certain area or geographic centre. The scale of regional centres in the NSW industry is such that entire regions can be potentially viewed as belonging to a single cluster. As Newcastle has demonstrated, on "triple-bottom-line" terms and more specifically in relation to being a magnet for SEI activity, the cluster strategy can work.

The important element is not purely physical proximity, but that a critical mass of dialogue and interplay is generated between industry members around the State. Without constructive collaboration, most NSW SEI businesses will be too under-resourced to keep up with the global pace of innovation.

9.4.2 Investment Attraction

Investment attraction is a crucial part of SEI development strategies. As the industry gets better developed over time, the emphasis of investment attraction tends to decline somewhat in relative importance as greater effort is placed on new and indigenous business creation. However, NSW should also offer fast-tracking support to promising local technologies that are rich in intellectual property early on.

The purpose of investment attraction under the SEI Fund option is to attract *strategic partners* who can contribute to industry development by helping to build the infrastructure for the local SEI industry through such things as:

- links to external markets;
- partnerships in R&D/innovation (including links to overseas R&D centres);
- contributions to the local skills base through on the job training and bringing in new highly skilled people; and
- a readiness to invest as venture capitalists in new businesses.

In building on the sense of partnership, rather than providing direct incentives to attract inward investment, the Government would be better advised to, where possible, stand ready to be a joint investor in projects and building capability that will spill over to the rest of the economy.

Investment attraction needs to be both professional and pro-active. It is not enough to wait for the phone to ring. It is necessary to identify SEI companies or particular sets of activities that complement the local industry and present them with a compelling case for investment in NSW.

Furthermore, investment attraction need not be pursued *at any cost*. Clearly, attracting a company that will add little value to the economy and which could even potentially cannibalise local businesses is not plausible. The Government is free to choose which companies to invite into the State, so its focus should therefore be on companies that have the ability and willingness to align their objectives in NSW with the broad SEI policy goals for State and regional development, and with environmental outcomes.

Appendix A The MMRF-Green Model

MMRF-Green is a very detailed dynamic, multi-sectoral, multi-regional model of Australia. The version of the model used for this project distinguishes 49 industries, 54 products, 8 states/territories and 56 sub-state regions. The industries are described in Table A.1.

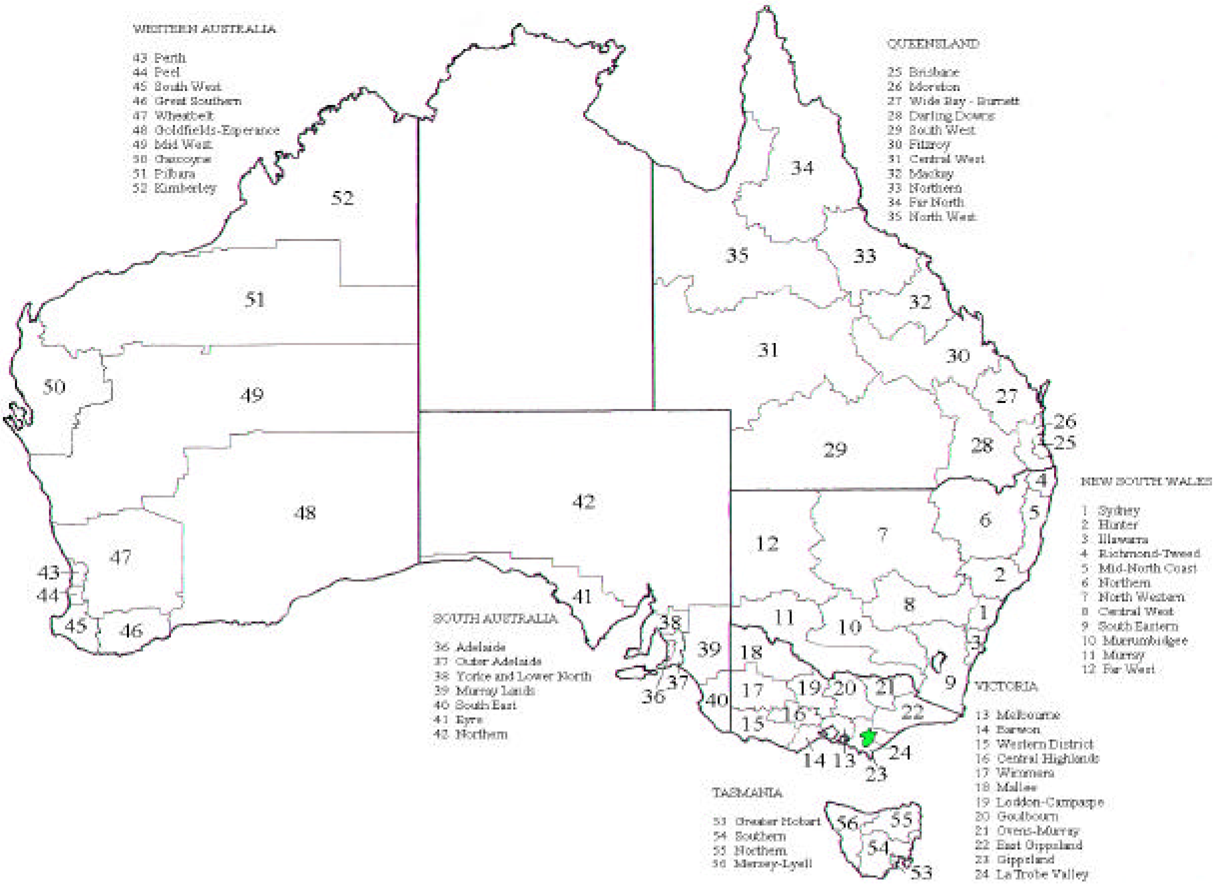
Table A.1: Goods and Services Recognised in MMRF-Green

Product name	Product description
1. Agriculture	All primary agricultural activities plus fishing
2. Forestry	All forestry activities, including logging and management
3. Iron ore	Mining of iron ore
4. Non-iron ore	Mining of non-iron ores, including gold and base ores
5. Black coal	Mining of black coal - thermal and metallurgical
6. Crude oil	Production of crude oil
7. Natural gas	Production of natural gas at well
8. Brown coal	Mining of brown coal
9. Food, beverages and tobacco	All secondary agricultural activities
10. Textiles, clothing, footwear	Manufacture of textiles, clothing and footwear
11. Wood and paper products	Manufacture of wood (including pulp) and paper products
12. Chemical prods. excl. petrol	Manufacture of basic chemicals and paints
13. Petroleum products	Manufacture of petroleum products
14. Building prods (not cement & metal)	Manufacture of non-metallic building products excl. cement
15. Cement	Manufacture of cement
16. Iron and steel	Manufacture of primary iron and steel.
17. Alumina and aluminium	Manufacture of alumina and aluminium
18. Other metal products	Manufacture of other metal products
19. Motor vehicles and parts	Manufacture of motor vehicles and parts
20. Other manufacturing	Other manufacturing including electronic equipment
21. Electricity – black coal	Electricity generation from black coal thermal plants
22. Electricity – brown coal	Electricity generation from brown coal thermal plants
23. Electricity – gas	Electricity generation from natural gas thermal plants
24. Electricity – oil prods.	Electricity generation from oil products thermal plants
25. Electricity – hydro	Electricity generation from renewable sources – hydro
26. Electricity – biomass	Electricity generation from renewable sources – biomass
27. Electricity – biogas	Electricity generation from renewable sources – biogas
28. Electricity – solar	Electricity generation from renewable sources – solar
29. Electricity - wind	Electricity generation from renewable sources – wind
30. Electricity supply	Distribution of electricity from generator to user
31. Urban gas distribution	Urban distribution of natural gas
32. Water and sewerage services	Provision of water and sewerage services
33. Construction services	Residential building and other construction services
34. Trade services	Provision of wholesale and retail trade services
35. Road transport services – passenger	Provision of road passenger transport services
36. Road transport services	Provision of road freight transport services

Product name	Product description
– freight	
37. Rail transport services – passenger	Provision of rail passenger transport services
38. Rail transport services – freight	Provision of rail freight transport services
39. Water transport services – passenger	Provision of water passenger transport services
40. Water transport services – freight	Provision of water freight transport services
41. Air transport services – passenger	Provision of air passenger transport services
42. Air transport services – freight	Provision of air freight transport services
43. Other transport services	Provision of water, air and rail transport services
44. Communication services	Provision of communication services
45. Financial/business services	Provision of financial and business services
46. Dwelling ownership	Services of dwellings
47. Public services	Provision of public services
48. Other services	Provision of all other services
49. Private motor vehicle ownership	Services of private motor vehicles

The geographic boundaries of the sub-state regions in MMRF-Green are shown in Figure A.1.

Figure A.1: Sub-state Regions Identified in MMRF-Green



MMRF-Green is founded on the MMR model.[103] The version of MMRF-Green used in this project was built in four stages. In the first stage, MMR was transformed into a dynamic system by the inclusion of dynamic mechanisms taken from the MONASH model. These were added as self-contained blocks, allowing MMRF-Green to include MMR as a special case. The second stage involved a range of developments designed to enhance the model's capacity for environmental analysis. In the third stage, a regional

103 A progress report on the development of the MMR model is given in Meagher, GA and Parmenter, BR, "Monash-MR: A Multi-regional CGE Model of Australia", *mimeo*, paper presented to the Venice Workshop on Transportation and Spatial CGE Models, Venice, 18-20 May 1993, p.25. In 1996, MMR was adapted for forecasting by the inclusion of enough dynamics to accumulate variables such as capital stocks and foreign debt over medium-run periods. This version was called the MMR Forecasting (MMRF) model. A detailed description of MMRF is given in Peter *et al*, MONASH-MRF: A Multi-sectoral, Multi-regional Model of the Australian Economy, *mimeo in preparation*. The current draft can be obtained by writing to Philip Adams, Centre of Policy Studies, PO Box 11E, Monash University, Victoria 3800, Australia.

disaggregation facility was added, which allows state-level results to be disaggregated down to sub-state regions. The fourth stage, undertaken for this project, focused on improvements to the model's treatment of renewable electricity generation.

A.1 Overview of MMR

MMR divides Australia into the six states and two territories. There are five types of agents in the model: industries, capital creators, households, governments, and foreigners. The number of industries is limited by computational constraints. For each industry in each region there is an associated capital creator. The sectors each produce a single commodity and the capital creators each produce units of capital that are specific to the associated sector. Each region in MMR has a single household and a regional government. There is also a federal government. Finally, there are foreigners, whose behaviour is summarised by export demand curves for the products of each region and by supply curves for international imports to each region.

MMR determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders so that each region's stock of productive resources reflects regional employment opportunities and relative rates of return.

The specifications of supply and demand behaviour coordinated through market clearing equations comprise the general equilibrium (GE) core of the model. There are two blocks of equations in addition to the core. They describe regional and federal government finances and regional labour markets.

A.1.1 Data Requirements for MMR

The GE core of MMR requires a multi-regional input-output table together with values for the elasticities of substitution in the CES nests of the specifications of technologies and preferences. The government finance block requires data on regional and Federal government revenues and outlays. The regional labour market block requires regional demographic, employment and labour force data.

The Australian Bureau of Statistics publishes suitable regional data for the government finance and labour market blocks. However, it does not compile multi-regional input-output (IO) tables. Disaggregating the national IO table used in the national GE model, MONASH, created IO data for the GE core. The regional disaggregation of the national IO table involved three steps:

- splitting of columns using regional proportions of industry outputs and final demands;
- splitting of rows using inter-regional trade data available from published sources;[104] and

[104] For example, see Quinlan, H., *Australia's Domestic Freight, 1986-87*, Centre for Transportation Policy Analysis, Wollongong University, Wollongong, 1991.

- application of RAS procedures to ensure equality in the multi-regional input-output table between the outputs and sales of regional sectors.

For values of primary-factor and domestic-import substitution elasticities, MMR relies on the MONASH national database. There are no reliable estimates of substitution elasticities between domestic products from different regional sources. High numbers are assumed to be appropriate — five times the value for domestic/import substitution elasticities. This means that different domestic varieties of a good are closer substitutes than are domestic and imported varieties.

A.1.2 Computing Solutions for MMR

MMR is a system of non-linear equations. It is solved using GEMPACK, a suite of programs for implementing and solving economic models. A linear, differential version of the MMR equation system is specified in syntax similar to ordinary algebra. GEMPACK then solves the system of non-linear equations as an Initial Value problem, using a standard method, such as Euler or midpoint. For details of the algorithms available in GEMPACK see Harrison and Pearson (1996). [105]

A.2 From MMR to MMRF-Green: Inclusion of MONASH dynamics

There are two main types of inter-temporal links incorporated into MMRF-Green:

- physical capital accumulation; and
- lagged adjustment processes.

A.2.1 Physical Capital Accumulation

It is assumed that investment undertaken in year t becomes operational at the start of year t+1. Thus, given a starting point value for capital in t=0, and with a mechanism for explaining investment through time, the model can be used to trace out the time paths of industry capital stocks.

Investment in industry i in state/territory s in year t is explained via a mechanism that relates investment to expected rates of return. The expected rate of return in year t can be specified in a variety of ways. As in MONASH, in MMRF-Green two possibilities are allowed for:

- static expectations; and
- forward-looking model-consistent expectations.

Under static expectations, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return. Under rational expectations the expected rate of return is set equal to the present value in year t of investing $1 in industry i in region r, taking account of both the rental earnings and depreciated asset value of this investment in year t+1 as calculated in the model.

105 Harrison W.J. and K.R. Pearson, Computing solutions for Large General Equilibrium Models Using GEMPACK, *Computational Economics,* Vol. 9, 1996, pp. 83-127.

A.2.2 Lagged Adjustment Processes

MONASH contains a number of lagged adjustment processes, but just one is included in MMRF-Green. This relates to the operation of the labour market in year-to-year policy simulations.

In comparative static analysis, one of the following two assumptions is made about the national real wage rate and national employment:

- the national real wage rate adjusts so that any policy shock has no effect on aggregate employment; or
- the national real wage rate is unaffected by the shock and employment adjusts.

MONASH's treatment of the labour market allows for a third, intermediate position, in which real wages can be sticky in the short run but flexible in the long-run and employment can be flexible in the short-run but sticky in the long-run. The same idea is applied in MMRF-Green. For year-to-year policy simulations, it is assumed that the deviation in the national real wage rate increases through time in proportion to the deviation in aggregate employment from its basecase-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the Non-Accelerating Inflation Rate of Unemployment (NAIRU) is exogenous.

A.3 MMRF-Green: Environmental Enhancements

MMRF-Green has been enhanced in a number of areas to improve its capability for environmental analysis. These enhancements include:

- an energy and gas emission accounting module, which accounts explicitly for each of the 45 industries and eight regions recognised in the model;
- equations that allow for inter-fuel substitution in electricity generation by region; and
- mechanisms that allow for the endogenous take-up of abatement measures in response to greenhouse policy measures.

A.3.1 Emissions Accounting

MMRF-Green tracks emissions of greenhouse gases at a detailed level. It breaks down emissions according to:

- emitting agent (49 industries and residential);
- emitting state or territory (8); and
- emitting activity (5).

Most of the emitting activities are the burning of fuels (black coal, natural gas, brown coal or petroleum products[106]). A residual category, named Activity, covers emissions such as fugitives and agricultural emissions not arising from fuel burning.

The resulting 49 x 8 x 5 matrix of emissions is designed to include all emissions except those arising from land clearing. Emissions are measured in terms of carbon dioxide equivalents, $C0_2$-e. The main source of data for the matrix of emissions is the 1999 National Greenhouse Gas Inventory published by AGO.

A.3.2 Inter-fuel Substitution

Inter-fuel substitution in electricity generated is handled using the "technology bundle" approach.[107] A variety of power-generating industries are distinguished based on the type of fuel used (see Table A.2). There is also an end-use supplier (*Electricity Supply*). The electricity generated in each state/territory flows directly to the local end-use supplier, which then distributes electricity to local and inter-state users. The end-use supplier can substitute between the different generation technologies in response to changes in their production costs. For example, the Electricity supply industry in NSW might reduce the amount of power sourced from coal-using generators and increase the amount sourced from gas-fired plants. Such substitution is price-induced; the elasticity of substitution between the various types of electricity used by the Electricity supply industry in each state is set to five.

For other energy-intensive commodities used in industry, MMRF-Green allows for substitution possibilities by including a weak form of input-substitution specification. If the price of say, cement, rises by 10 percent relative to other inputs to construction, the construction industry will use 1 percent less cement and, to compensate, a little more of labour, capital and other materials. In most cases, as in the cement example, we have imposed a substitution elasticity of 0.1. For important energy goods, *petroleum products*, *electricity supply* and *urban gas distribution*, the substitution elasticity in industrial use is 0.25. This input substitution is driven by price changes and so is especially important in emission-policy scenarios, which makes outputs of emitting industries more expensive.

A.4 MMRF-Green: Disaggregation to Sub-State Regions

A.4.1 Regions in MMRF-Green

Few multi-regional models of the Australian economy have the level of sectoral detail supported by MMRF-Green. This detail is usually more than adequate for contributions to public discussions on the effects of changes in policies concerning taxes, trade and the environment. However, people wanting to use MMRF-Green in business and public sector planning are often frustrated by the lack of relevant regional detail. This applies especially to people interested in regional adjustment issues.

It is with these people in mind that MMRF-Green incorporates a top-down method that enables disaggregation of state-level results for output, employment and greenhouse-gas emissions down to projections for 56 sub-state regions (Figure A.1). The method is an

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106 Each of these fuels is identified as a separate commodity within the model.

107 For example, see Hinchy, M and Hanslow, K, *The MEGABARE Model: Interim Documentation*, ABARE, Canberra, 1996.

adaptation of the regional disaggregation method first devised by Leontief *et al*.[108], in the context of an input-output model, and first applied to sub-state regions in Australia by Adams and Dixon.[109]

These regions are based on the Statistical divisions defined in the Australian Standard Geographical Classification (ABS catalogue number 1216.0) although MMRF-Green's division structure differs slightly from that of the ABS: the ABS's Darwin and *Northern Territory — balance* divisions are combined into one division, Northern Territory. Similarly, Canberra and *ACT — balance* are combined into one division, Australian Capital Territory. Note that both territories are distinguished as separate regions in MMRF-Green. Hence, the top-down disaggregation facility provides no additional detail for them. A slightly different regional classification for WA than that defined by the ABS is adopted based on the classification used by the WA Department of Commerce. Finally, the energy intensive La Trobe Valley in Victoria is identified as a separate region (region 24), with Gippsland (region 23) defined to include all areas in the ABS statistical division *Gippsland* other than the La Trobe Valley.

A.4.2 Methodology

The methodology for top-down regional disaggregation involves firstly classifying each of MMRF-Green's industries (Table A.1) into one of two categories: state and local. State industries produce commodities that are readily traded across sub-state regional boundaries. Examples are most agricultural and mining industries. The regional outputs of industries producing state commodities are assumed to move in line with the state-wide percentage rates of change calculated by MMRF-Green.

Local industries produce commodities for which demand within each sub-state region is satisfied mainly from production in that region. Examples include perishable items and services like wholesale and retail trade. The outputs in each region of industries producing local commodities are modelled as depending mainly on demand within the region. In calculating the local demand for the output of local industry j, MMRF-Green takes account of:

- intermediate and investment demands both by local industries and by state industries located in the sub-state region;
- the region's household demands, which are a function of population and employment changes and of the change in consumption at the state level;
- government demand; and
- if industry j's output is a margin commodity like transport, the usage of industry j's product in facilitating the flow of local and state commodities within the sub-state region and international export flows out of the region.

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108 Leontief, W., A. Morgan, K. Polenske, D. Simpson and E. Tower, 'The Economic Impact -- Industrial and Regional -- of an Arms Cut', *Review of Economics and Statistics*, XLVII, August 1965, pp. 217-41.

109 Adams, P.D. and P.B. Dixon, "Prospects for Australian Industries, States and Regions: 1993-94 to 2001-02", *Australian Bulletin of Labour*, Vol. 21, No. 2, June 1995, pp. 87-108.

This gives our regional calculations a multiplier property: the effect on a sub-state region's overall level of activity of a favourable mix of state industries is multiplied through induced effects on the output and employment of the region's local industries.

In the regional disaggregation, we allow for the possibility of some demand for local commodities outside the region of their production, but not from outside the state in which the region is located. This is because the data imply that for almost all commodities there is at least some imbalance at the sub-state regional level between demand and supply.

A.5 MMRF-Green: Enhanced Treatment of Renewables

Prior to this project, MMRF-Green recognised just one renewable generating industry in each state. The cost structure of this generic industry was modelled on the cost structure of the average hydro plant. Sales of this industry were concentrated in the states in which hydro generation was present (TAS, VIC, NSW and to a small extent QLD).

For this project we have incorporated a more detailed treatment of renewable technologies. Instead of one industry, we have created five separate industries each producing electricity from a specific renewable source. The five sources are hydro, biomass, biogas, solar and wind. In broad terms, the production technologies for biomass and biogas generation are more labour intensive than for solar and wind generation, and less intensive in the usage of machinery and equipment. The production technology for hydro generation is about halfway between each of these extremes.

The regional distribution of renewable generation is shown in Table A.2 below. Also shown, for sake of comparison, is the regional pattern of fossil-fuel generation.

Table A.2: Electricity Generation by Fuel (PJ) in 1999

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Electricity generated by:								
Black coal	233.7668	0.0000	113.6969	17.0366	34.3996	0.0000	0.0000	0.0
Brown coal	0.0000	178.8000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
Natural gas	7.0061	2.8235	10.2782	17.2967	32.6925	0.0000	7.7031	0.0
Oil products	0.5584	0.0847	1.6365	0.2237	4.1168	0.0000	1.5799	0.0
▪ Hydro	24.0853	3.4125	1.4227	0.0000	0.0000	29.7794	0.0000	0.0
▪ Biomass	1.5116	1.3091	1.6809	0.0156	0.0151	0.2677	0.0000	0.0
▪ Biogas	0.5939	0.7384	0.0229	0.0405	0.0043	0.0000	0.0000	0.0
▪ Solar	0.5863	0.1340	0.1435	0.0041	0.0321	0.0000	0.0000	0.0
▪ Wind	0.0255	0.2479	0.0091	0.0008	0.0068	0.0000	0.0000	0.0
Total	**268.3563**	**187.3277**	**128.8908**	**34.6181**	**71.2670**	**30.0472**	**9.2829**	**0.0**

Source: MMRF-Green database for 1999.

Appendix B Assumptions Used in the Baseline (no measures) Projection

In generating the baseline (no measures) forecasts, the following data is used:

- state/territory macroeconomic forecasts from Access Economics;
- national-level assumptions for changes in industry production technologies and in household preferences from CoPS; and
- forecasts for the quantities of agricultural and mineral exports, and estimates of capital expenditure on major minerals and energy projects from various sources, such as state government agencies, the Australian Bureau of Agricultural and Resource Economics (ABARE), and the National Electricity Market Management Company (NEMCO).

B.1 Macroeconomic Inputs

Table B.1 shows the assumptions for selected macroeconomic variables in terms of average annual growth rates over the period 1999 to 2020.

Table B.1: Macroeconomic Assumptions for the Baseline (no measures) Scenario (average annual growth rates, 1999-2020)

	Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	AUS
1	Real private consumption	2.8	2.8	3.7	2.1	3.7	1.5	4.5	2.5	3.0
2	Real investment	3.1	2.1	4.4	1.8	4.8	2.0	6.2	2.8	3.3
	Real public consumption:									
3	▪ total	2.8	2.4	3.6	1.8	4.2	1.4	4.6	2.5	2.9
4	▪ regional	2.8	2.4	3.6	1.8	4.2	1.4	4.6	2.1	2.9
5	▪ federal	2.8	2.4	3.6	1.8	4.2	1.4	4.6	2.6	2.9
6	International export volumes	5.5	7.3	5.2	5.2	5.9	4.5	9.2	7.1	5.9
7	International import volumes	5.2	5.9	5.9	3.3	7.0	3.0	8.6	8.1	5.7
8	Real GDP/GSP	2.9	2.9	3.4	2.0	4.0	1.6	5.6	2.3	3.0
9	Aggregate employment	1.1	1.1	1.8	0.6	2.0	0.3	1.8	1.3	1.3
10	Aggregate capital stock	4.5	4.2	4.6	3.5	5.6	2.3	8.3	4.3	4.5
11	CPI	2.1	2.1	2.5	2.7	1.7	2.5	1.4	2.1	2.2
12	GDP/GSP deflator	2.6	2.2	2.8	3.1	1.8	3.0	0.7	2.7	2.5

Source: MMRF-Green Modelling Results

Real GDP is assumed to grow at an average annual rate of 3.0 percent (row 8). The states/territories with the best growth potential are NT (5.6 percent per annum annual growth in real GSP) and WA (4.0 percent). The states with the worst growth potential are TAS (1.6 percent) and SA (2.0 percent). In general, the forecast growth rates are in line with the long-run growth potential for each economy. Note, however, that for QLD and WA the forecast growth rates are below the average rates of the last ten years. Factors such as the prospect of a prolonged period of slow growth in Japan and slower long-term growth in the US economy, make it unlikely that the foreign-export-oriented states like QLD and WA can sustain their recent strong performance.

Over recent years, real private consumption has grown faster than real GSP in most regions. However, as can be seen by comparing rows 1 and 8 in Table B.1, we expect that real consumption will grow roughly in line with real GSP in each region over the forecast period.

Growth in real investment (row 2) at the national level is forecast to be a fairly modest 3.3 percent. This reflects initial conditions. 1999 was a very strong year for investment, and only modest investment growth is required to maintain the historically normal economy-wide investment/capital ratio of three percent. Forecast differences across regions reflect a combination of different initial conditions, different industrial compositions and specific assumptions about large projects such as the Comalco aluminium plant in QLD.

Over the past fifteen years real international exports (row 6) and real international imports (row 7) have grown rapidly relative to real value added (row 8) in each region. This reflects several factors: declining transport costs; improvements in communications; reductions in protection in Australia and in our major trading partners; and technological changes favouring the use of import-intensive goods such as computers and communication equipment. All these factors are expected to continue through the forecast period, leading to further increases in the ratios of the volume of international trade to real value added.

Employment (row 9) in each region is assumed to grow at rates that are consistent with long-run productivity trends in each state. For Australia as a whole, long-run productivity growth is set at 1.7 percent. For the states/territories we assume long-run productivity growth rates of: 1.8 percent (NSW), 1.8 percent (VIC), 1.6 percent (QLD), 1.4 percent (SA), 2.0 percent (WA), 1.3 percent (TAS), 3.6 percent (NT) and 1.0 percent (ACT).

In some cases, MMRF-Green departs from the Access story. For example, it is assumed that foreign-import growth will be stronger in all states/territories than Access is forecasting for the years 2000 to 2002. This results from the check that the microeconomic model puts on the macroeconomic forecasts. When the macroeconomic forecasts are imposed, MMRF-Green must produce a microeconomic story that is consistent with the macroeconomics. Import growth in MMRF-Green is explained primarily by growth in the level and structure of domestic demand and by relative price movements. For example, if investment growth is strong, the model wants to project strong import growth because investment is an import-intensive activity.

Similarly, the model will want to project strong import growth if the real exchange rate appreciates, because this lowers the prices of imports relative to the prices of locally produced goods. In the forecasting simulations, any tension between the standard MMRF-Green mechanisms and the exogenous forecasts for foreign imports is reconciled by allowing twists in domestic purchasers' import/domestic preferences. But care is taken to ensure that these twists are plausible relative to historical experience.

B.2 Assumptions for Changes in Technology and Tastes

Table B.2 shows the assumptions for changes in the preferences of households and for changes in the production technologies of industries. These are applied uniformly across regions. The numbers are based on extrapolated trends calculated from a MONASH simulation for the period 1986-87 to 1996-97.

Table B.2: Industry Technology and Household Taste Assumptions for the Baseline (no measures) Scenario (average annual percentage changes)*

	Household	**Technology:**		
Commodities	Preferences[a]	Intermediate input using[b]	Primary factor using[c]	Industries
Agriculture	#	0.0	-1.2	Agriculture
Forestry	#	1.7	0.0	Forestry
Iron ore	#	-0.3	-2.0	Iron ore
Non-iron ore	#	-1.6	-1.2	Non-iron ore
Black coal	#	-1.1	0.0	Black coal
Crude oil	#	0.0	0.0	Crude oil
Natural gas	-1.3	0.5	0.0	Natural gas
Brown coal	#	-0.5	0.0	Brown coal
Food, beverages and tobacco	0.6	0.2	-0.6	Food, beverages and tobacco
Textiles, clothing and footwear	-2.7	-0.4	-0.9	Textiles, clothing and footwear
Wood and paper products	0.1	0.1	-0.1	Wood and paper products
Chemical products excl. Petrol	2.1	2.6	0.0	Chemical products excl. Petrol
Petrol	0.0	-1.0	0.0	Petroleum products
Aviation gasoline	0.0	-1.0		
Aviation turbine fuel	0.0	-1.0		
Diesel	0.0	-1.0		
LPG	0.0	0.5		
Other petroleum products	-2.7	-1.0		
Building prods (not cement & metal)	0.1	0.5	-0.6	Building prods (not cement & metal)
Cement	#	-1.2	-0.2	Cement
Iron and steel	#	1.3	-0.7	Iron and steel
Alumina and aluminium	#	2.0	-1.2	Alumina and aluminium
Other metal products	-1.3	1.3	0.0	Other metal products
Motor vehicles and parts	0.0	2.5	-0.2	Motor vehicles and parts
Other manufacturing	0.7	3.7	-0.9	Other manufacturing
Electricity – black coal	#	0.0	-1.0	Electricity – black coal
Electricity – brown coal	#	0.0	-1.0	Electricity – brown coal
Electricity – gas	#	4.0	-1.0	Electricity – gas
Electricity – oil prods.	#	0.0	0.0	Electricity – oil prods.
Electricity – hydro	#	0.5	-2.0	Electricity – other
Electricity – biomass	#	0.5	-2.0	Electricity – hydro
Electricity – biogas	#	0.5	-2.0	Electricity – biomass
Electricity – solar	#	0.5	-2.0	Electricity – biogas
Electricity - wind	#	0.5	-2.0	Electricity – solar
Electricity supply	0.3	0.0	-1.0	Electricity - wind
Urban gas distribution	0.3	0.6	-1.4	Urban gas distribution
Water and sewerage services	-0.5	-0.2	-1.2	Water and sewerage services
Construction services	0.0	1.8	0.0	Construction services
Wholesale trade, retail trade, accom	-2.1	-1.8	0.0	Wholesale trade, retail trade, accom
Road transport services – passenger	-1.6	0.5	-0.4	Road transport services – passenger
Road transport services – freight	#	0.5	-0.4	Road transport services – freight
Rail transport services – passenger	-0.1	-0.2	-1.1	Rail transport services – passenger
Rail transport services – freight	#	-0.2	-1.1	Rail transport services – freight

	Household	Technology:		
Water transport services – passenger	-6.2	-5.0	-0.6	Water transport services – passenger
Water transport services – freight	#	-5.0	-0.6	Water transport services – freight
Air transport services – passenger	1.7	-2.1	-1.8	Air transport services – passenger
Air transport services – freight	#	-2.1	-1.8	Air transport services – freight
Other transport services	-0.3	0.8	0.0	Other transport services
Communication services	0.0	5.0	-2.2	Communication services
Financial and business services	1.9	3.3	-0.9	Financial and business services
Dwelling ownership	0.0	0.0	-0.8	Dwelling ownership
Public services	0.1	0.0	-0.2	Public services
Other services	1.2	1.6	0.0	Other services
Private motor vehicle ownership	-0.9	0.0	0.0	Private motor vehicle ownership

* The symbol # indicates that the underlying flow is negligible
a Annual rate of shift of consumption function.
b Annual rate of change of use of the commodity identified on the left-hand panel per unit of output of industries using the commodity.
c Annual rate of change of use of all primary factors (labour, capital and agricultural land) per unit of production of the industry identified in the right-hand panel.

Assumptions for household tastes are summarised in the first column of numbers in Table B.2. A positive (negative) number indicates that it is assumed that household usage of the relevant commodity will increase (decrease) relative to the movements that are implied in the forecasts by changes in household aggregate expenditure and by changes in relative prices. For example, it is assumed that consumption of *Financial and business services* will increase at a rate 1.9 percent a year faster than can be explained on the basis of changes in prices and changes in the average budget of households.

The second column of numbers in Table B.2 shows the initial assumptions for the average annual rates of change in the usage of commodities as intermediate inputs per unit of production in industries, and as inputs per unit of capital creation. Negative numbers indicate that technological change is commodity-saving. Positive numbers indicate that it is commodity-using. For example, it is assumed initially that in each year industries will increase their usage of *communication services* by 5.0 percent more than their outputs.

The exogenous shocks to produced-input technologies impose a cost/saving on the industries that use the inputs. For example, industries that utilise communication services will suffer a cost increase when forced to use 5.0 percent more of those services per unit of output. To offset these cost effects, a simultaneous uniform adjustment is made to the technology coefficients applying to the entire user's inputs (produced and primary) so that there is no net effect on the user's costs.

The assumptions in the second column for energy commodities are of special importance to this study. They show that through the forecast period industries will become more intensive in their use of natural gas and less intensive in their use of black and brown coal.[110] The intensity with which industries use crude oil is assumed not to change. For derived fuels, industries will become more intensive in their use of LPG, and less intensive in their use of other petroleum products. It is assumed that there is zero change in the intensity of use of electricity supply: increased electricity efficiency for electrical equipment is offset by more intensive usage of electrical equipment. To understand the numbers for the electricity-generator products, note that these products are sold only to

110 We assume that there is more scope for improved efficiency in the use of black coal than for brown coal based on improvements already achieved.

the electricity supply industry, thus the assumptions for the generator products are indicative of historical trends in the fuel mix of electricity supply.

The initial assumptions for each industry concerning average annual changes in primary-factor usage per unit of output are shown in the fourth column of Table B.2. Primary-factor inputs in MMRF-Green comprise labour, capital and agricultural land. For example, the initial assumption for *Agriculture* is that output will increase on average by 1.2 percent a year relative to the industry's overall usage of primary factors.

For the electricity industries, it is assumed that annual improvements in the rate of factor-saving technological change 1.0 percent for the fossil fuel generators and 2.0 percent for the renewable generators. These rates are less than the historical trends, estimated to be 1.5 percent per year and 2.5 percent per year. The difference of 0.5 percentage points per year is the estimate of the contribution made by Energy Market Reform (EMR) to productivity growth in electricity prior to 2000.

Note that, in Table B.2, the first two columns have the dimension of the commodities of the model, while the final column has the dimension of the industries of the model. In MMRF-Green, the number of commodities can be different from the number of industries, because some industries produce more than one commodity. Currently, the only multi-product industry is *petroleum products* which produces six commodities: *petrol, aviation gasoline, aviation turbine fuel, diesel, LPG and other petroleum products*.

Table B.3 summarises the technical assumptions for the usage of fuels per unit of industrial output and for the usage of fuels per unit of electricity generation in terms of two commonly used measures of efficiency — energy technical efficiency and supply efficiency. Energy technical efficiency is defined as minus a weighted average of the use of primary and derived fuels per unit of output in all industries using those fuels other than the electricity generators. For Australia as a whole, a value of 0.5 percent per annum is assumed, implying that in each year industries other than electricity generators will use 0.5 percent less fuel (primary and derived) per unit of output. Supply efficiency is defined as minus a weighted average of the use of primary fuels per unit of electricity generation. For Australia as a whole, a value of 0.6 percent per annum is assumed, implying that in each year electricity-generating industries will use 0.6 percent less primary fuels per unit of output.

Table B.3: Baseline (no measures) Assumptions for Energy Efficiency (average annual percentage growth rates 1999-2020)

States	*Energy technical efficiency improvement*[a]	*Supply efficiency improvement*[b]
AUS	0.5	0.6
NSW	0.5	0.9
VIC	0.4	0.5
QLD	0.5	0.7
SA	0.4	0.2
WA	0.5	0.3
TAS	0.4	0.0
NT	0.5	0.1
ACT	0.4	0.0

a Energy technical efficiency is defined as minus a weighted average of the use of primary and derived fuels per unit of output in all industries using those fuels other than electricity. Thus a value of 0.5 percent per annum implies that industries other than electricity use annually 0.5 percent less fuels (primary and derived) per unit of output.

b Supply efficiency is defined as minus a weighted average of the use of primary fuels per unit of electricity generation. Thus a value of 0.6 percent per annum implies that electricity-generating industries use annually 0.6 percent less primary fuels per unit of output.

B.3 Assumptions for Exports and for Large Resource and Electricity Projects

Table B.4 shows assumptions for the quantities of agricultural and mineral exports. These reflect ABARE projections to 2006 and exogenously imposed long-term trends for the remaining years to 2020.

MMRF-Green's theory of investment relates year-to-year changes in capital expenditure to year-to-year changes in rates of return. This is appropriate for most industries where the evolution of investment through time is relatively smooth. However, for industries in the resource and electricity sectors, investment is seldom smooth. Accordingly, in forecasting we complement the standard MMRF-Green investment theory with extraneous information relating to incremental investment changes in the resource and electricity industries. Currently, the primary source of information for planned projects in the resource sector is ABARE (2001a). The primary source of information for future electricity investments is NEMCO, which provides data via personal communication. Information from these sources covers the years through to 2006. Thereafter, we impose long-term trends based partly on trends projected for the years 1995 to 2006.

Notable projects accommodated for in the Baseline (no measures) are:

- the Victoria-Tasmania natural gas interconnection, which is assumed to begin operation in 2004;
- the Victoria-Tasmania electricity connection (Basslink);
- the PNG-QLD natural gas pipeline;
- the expansion of both aluminium smelting and alumina refining capacity in QLD, WA and the NT; and
- several new gas-fired electricity plants, mainly in QLD, NSW and WA.

Table B.4: Assumptions for Exports for the Baseline (no measures) (average annual percentage changes) *

Variable	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Export volumes:								
Agriculture	2.2	2.9	1.9	1.6	3.3	3.3	1.8	#
Iron ore	#	#	#	2.6	3.0	3.4	#	#
Non-iron ore	2.1	3.1	0.4	2.2	4.5	2.5	3.3	#
Black coal	2.4	#	3.1	#	#	#	#	#
Crude oil	#	-0.5	#	#	1.5	#	1.5	#
Natural gas	#	#	#	#	4.0	#	#	#
Petroleum products	1.5	1.5	1.5	#	1.5	#	#	#
Alumina and aluminium	2.0	3.1	7.9	#	4.6	1.5	4.9	#

* The symbol # indicates that the underlying flow is negligible.

Appendix C Baseline (no measures) Scenario: Outcomes

This appendix sets out the outcomes of the Baseline (no measures) Scenario in respect of:

- industry output;
- greenhouse gas emissions; and
- electricity generation by fuel

Reflecting the fact that this scenario represents the status quo, macroeconomic outcomes are the same as the macroeconomic assumptions used in the model, which were set out in Table B.1.

Table C.1 sets out the industry output results of the model for Scenario One.

Table C.1: Baseline (no measures) Scenario: Output by Industry (average annual growth rates, 1999–2020)

Industry	NSW	AUS
Agriculture	2.3	2.8
Forestry	2.9	3.0
Iron ore	0.0	2.7
Non-iron ore	-2.6	2.0
Black coal	2.1	2.5
Crude oil	0.0	1.7
Natural gas	0.0	3.5
Brown coal	0.0	1.5
Food, beverages and tobacco	3.4	4.1
Textiles, clothing and footwear	2.3	3.0
Wood and paper products	2.0	2.3
Chemical products excl. Petrol	3.8	4.2
Petroleum products	0.8	1.1
Building prods (not cement & metal)	2.4	2.6
Cement	0.3	0.7
Iron and steel	4.0	4.2
Alumina and aluminium	1.7	4.5
Other metal products	4.0	4.7
Motor vehicles and parts	1.4	2.1
Other manufacturing	4.9	4.7
Electricity — black coal	2.1	2.4
Electricity — brown coal	0.0	2.5
Electricity — gas	4.2	4.0
Electricity — oil prods.	0.0	0.0
Electricity — hydro	0.5	0.8
Electricity — biomass	0.0	0.5
Electricity — biogas	0.0	0.0
Electricity — solar	0.0	0.0
Electricity — wind	0.0	0.0
Electricity supply	2.2	2.4

Industry	NSW	AUS
Urban gas distribution	2.9	3.0
Water and sewerage services	2.9	2.9
Construction services	3.2	3.3
Wholesale trade, retail trade, accommodation	1.8	2.1
Road transport services — passenger	2.1	2.2
Road transport services — freight	3.6	4.0
Rail transport services — passenger	2.2	2.3
Rail transport services — freight	2.4	2.7
Water transport services — passenger	1.2	1.4
Water transport services — freight	0.1	0.5
Air transport services — passenger	3.8	5.3
Air transport services — freight	2.6	2.7
Other transport services	3.1	3.5
Communication services	7.8	7.9
Financial and business services	5.7	5.8
Dwelling ownership	4.0	3.8
Public services	2.7	2.8
Other services	3.8	4.0
Private motor vehicle ownership	1.2	1.5

Table C.2 sets data on CO_2-e emissions over the period 1999 to 2020.

Table C.2: Baseline (no measures) Scenario: C02-e Emissions by Major Source

	NSW	AUS
Average annual growth rates (1999-2020)		
Energy sector, total	1.2	1.7
• Fuel combustion	1.2	1.7
• • Electricity	0.8	1.3
• • Transport	1.2	1.6
• • Other industries	1.8	2.3
• • Household consumption	0.3	0.4
• Fugitive emissions from fuels	2.1	2.1
Industrial processes	1.3	2.5
Agriculture	2.3	2.8
Waste	1.8	2.0
LUCF	2.5	2.6
Total	**1.5**	**1.9**
Levels (Mt CO2-e) (1999)		
Energy sector, total	113.9	363.6
• Fuel combustion	108.4	333.5
• • Electricity	49.1	162.1
• • Transport	28.4	77.2
• • Other industries	29.7	90.8
• • Household consumption	1.1	3.4
• Fugitive emissions from fuels	5.5	30.1
Industrial processes	2.2	10.4
Agriculture	29.9	95.2
Waste	5.5	16.3
LUCF	-5.2	-26.5
Total	**146.2**	**459.0**

	NSW	AUS
Levels (Mt CO2-e) (2010)		
Energy sector, total	130.9	446.2
• Fuel combustion	124.0	408.3
• Electricity	54.5	193.7
• Transport	32.5	93.7
• Other industries	35.8	117.4
• Household consumption	1.1	3.5
• Fugitive emissions from fuels	6.9	37.9
Industrial processes	2.5	13.7
Agriculture	37.6	130.7
Waste	6.8	20.8
LUCF	-7.0	-36.2
Total	**170.8**	**575.2**
Levels (Mt CO2-e) (2020)		
Energy sector, total	147.5	518.6
• Fuel combustion	139.0	471.5
• Electricity	58.7	213.0
• Transport	36.2	107.5
• Other industries	43.0	147.3
• Household consumption	1.2	3.7
• Fugitive emissions from fuels	8.5	47.0
Industrial processes	2.8	17.7
Agriculture	48.2	171.5
Waste	8.0	24.5
LUCF	-8.7	-45.3
Total	**197.9**	**686.9**

Table C.3 shows the level of electricity generation by fuel over the period 1999 to 2020.

Table C.3 Baseline (no measures) Scenario: Electricity Generation by Fuel and State

	NSW	AUS
Average annual growth rates (1999-2020)		
Black coal	2.1	2.4
Brown coal	0.0	2.5
Gas	4.2	4.0
Liquid fuel	0.0	0.0
• Hydro	0.5	0.8
• Biomass	0.0	0.5
• Biogas	0.0	0.0
• Solar	0.0	0.0
• Wind	0.0	0.0
Total energy generated	**2.1**	**2.5**
Levels (PJ) (1999)		
Black coal	233.8	398.9
Brown coal	0.0	178.8
Gas	7.0	77.8
Liquid fuel	0.6	8.2
• Hydro	24.1	58.7
• Biomass	1.5	4.8
• Biogas	0.6	1.4
• Solar	0.6	0.9

	NSW	AUS
• Wind	0.2	0.3
Total energy generated	**268.4**	**729.8**
Levels (PJ) (2010)		
Black coal	293.2	517.1
Brown coal	0.0	248.0
Gas	11.0	119.5
Liquid fuel	0.6	8.2
• Hydro	25.4	65.3
• Biomass	1.5	5.1
• Biogas	0.6	1.4
• Solar	0.6	0.9
• Wind	0.2	0.3
Total energy generated	**333.2**	**965.8**
Levels (PJ) (2020)		
Black coal	364.1	655.2
Brown coal	0.0	298.0
Gas	16.6	178.0
Liquid fuel	0.6	8.2
• Hydro	26.7	69.8
• Biomass	1.5	5.4
• Biogas	0.6	1.4
• Solar	0.6	0.9
• Wind	0.2	0.3
Total energy generated	**411.0**	**1217.0**

Appendix D Baseline (with measures) Scenario: Assumptions

This appendix sets out the key assumptions used in the development of the Baseline (with measures) Projection, in particular, the incorporation of the key existing measures that governments have put in place that will impact on greenhouse gas emissions and hence energy-related industries.

D.1 Methodology

In computing the Baseline (no measures) scenario, forecasts and information available from outside sources such as Access Economics were used. To accommodate this information, numerous naturally endogenous variables were exogenised. These included the volumes of agricultural exports and most macro variables.

To allow such naturally endogenous variables to be exogenous, an equal number of naturally exogenous variables were made endogenous. For example, to accommodate forecasts for the volumes of agricultural exports were made endogenous variables that locate the positions of foreign demand curves. To accommodate forecasts for macro variables, various macro coefficients were made endogenous such as the average propensity to consume.

However, when accommodating the effects of policy, the naturally endogenous variables, such as the volumes of agricultural exports and macro variables, which were exogenous in the baseline (no measures) scenario must be made endogenous. This allows them to respond to the exogenous changes under consideration. Correspondingly, naturally endogenous variables, such as the positions of foreign demand curves and macro coefficients, must be exogenous. They are set at the values revealed in the baseline (no measures) case.

In making these closure changes, a number of assumptions regarding important aspects of the economy are made as set out below.

D.1.1 Labour Markets

At the national level, it is assumed that the deviation in the consumer's real wage rate (ie, the nominal wage rate deflated by the CPI) from its baseline (no measures) level, increases in proportion to the deviation in employment from its baseline (no measures) level. The coefficient of proportionality is chosen so that the employment effects of a shock to the economy are largely eliminated after five years. In other words, after about five years, the costs of an unfavourable shock are realised almost entirely as a fall in the national real wage rate, rather than a fall in employment.

At the regional level, it is assumed that labour is mobile between state economies. Labour is assumed to move between regions so as to maintain inter-state wage and unemployment rate differentials at their levels in the baseline (no measures) case. Accordingly, regions that are favourably affected by the measures will experience increased employment and population at the expense of regions that are less favourably affected.

D.1.2 Private Consumption and Investment

Consumption expenditure of the regional household is determined by Household Disposable Income (HDI). Since budget constraints are not imposed on the business sector or on governments, regional economies will run trade deficits/surpluses to the extent that aggregate regional expenditure levels are greater than/less than aggregate regional incomes. The deficits or surpluses can be held with other agents in other regions, with foreigners or with both regional agents and foreigners.

It is assumed that in each year, investment in each regional industry will deviate from its value in the baseline (no measures) projection in line with the deviation in the expected rate of return on the industry's capital stock. Investors are assumed to be myopic, implying that expected rates of return move with contemporaneously observed rates of return.

D.1.3 Rates of Return on Capital

In deviation simulations, MMRF-Green allows for short-run divergences in rates of return on industry capital stocks from their levels in the baseline (no measures) forecasts. Such divergences cause divergences in investment and hence capital stocks. The divergences in capital stocks gradually erode the divergences in rates of return, so that in the long-run rates of return on capital over all regional industries return to their baseline (no measures) levels.

D.1.4 Production Technologies

MMRF-Green contains many types of technical change variables. In the deviation simulation it is assumed that all technology variables, other than those used in the implementation of shocks, have the same values as in the baseline (no measures) simulation.

D.2 Description of the Measures

Nine policy measures are included in the with-measures scenarios. The following is a list of these measures along with a description of how they were modelled.

D.2.1 Supply-side

Energy market reform (EMR) — It is assumed that EMR will bring an extra 0.5 percent per annum increase in primary factor productivity in the electricity generating and supply industries between 1999 and 2020. In the baseline (no measures) scenario it is assumed that productivity increases at the rate of 1.0 percent per annum in fossil-fuel generation, and by 2.0 percent per annum in renewable generation. Thus, in the with-measures scenarios, productivity increases by 1.5 percent per annum in the fossil-fuel industries, and by 2.5 percent in the renewable industries. The additional growth is based on an estimate of the effects of EMR activities post 1999. It does not take account of the EMR changes implemented prior to 1999.

QLD cleaner energy strategy — This is modelled as autonomous annual shifts towards gas-fired electricity generation and away from coal-fired generation in QLD sufficient to increase the share of gas-fired generation in total generation in QLD to 13.1 percent by 2010 and to keep it at that level through to 2020.

Generator efficiency standards — It is assumed that efforts in updating generators will result in a reduction (relative to baseline (no measures) levels) in 2010 of 2 Mt of emissions from black coal generation, 2 Mt from brown coal generation, and 1 Mt from gas generation. These reductions are achieved by cost-neutral increases (relative to baseline (no measures) levels) in the annual-rate of fuel-saving technological progress in fossil-fuel generation. For the period 2010 to 2020, it is assumed that the increases in the annual rate of fuel saving technological progress deduced for the period 1999 to 2010 continue. Thus, by 2020, the emissions savings from this measure is around 10 Mt.

Mandatory renewable energy targets (MRET) and extension to Green Power — The MRET target obliges wholesale purchasers of electricity to proportionately contribute towards the generation of an additional 9500 GWh of renewable energy per year by 2010. This translates to an additional 34.2 PJ of generated electricity. The scheme is implemented via autonomous annual shifts towards renewable electricity generation and away from fossil-fuel generation, sufficient to hit the renewable target in 2010. These shifts are quantity neutral, that is, one PJ increase in renewable generation is matched by one PJ decrease in fossil generation. However, they are not cost neutral since renewables are assumed to be a more costly form of generation, in line with ABARE estimates.[111] For the period 2010 to 2020, it is assumed that an MRET-like scheme operates to maintain the renewable share in total generation at its level achieved in 2010 with the MRET in place.

In Scenario Four, the extended MRET requires wholesale purchasers of electricity to proportionately contribute toward the generation of an additional 19,000 GWh (or 68.4 PJ) of renewable energy by 2010. In other words, the extended MRET target is twice as demanding as the existing MRET target embodied in Scenario Two.

Greenhouse gas abatement program (GGAP) and greenhouse-friendly certification program — This program provides support to activities that are likely to result in substantial emission reductions or substantial sink enhancement up to 2012. It is assumed that the GGAP will lead to reductions (relative to baseline (no measures) levels) in emissions from the stationary energy sector in each state in accordance with information provided by the Australian Greenhouse Office. It is assumed that GGAP will not continue after 2012.

D.2.2 Demand-side

Greenhouse challenge program (GCP) — This is described as a cooperative program between industry and government whereby companies undertake action to abate their greenhouse gas emissions through no regrets energy efficiency and other measures. It is modelled as a combination of improved (relative to baseline (no measures) levels) generation efficiency and improved energy efficiency in industrial usage targeted to achieve an Australia-wide reduction in emissions of 5.8 Mt. This is the estimate of the measure's impact based on data provided by GCP participants and published in the AGO document, *Greenhouse Challenge*, February 2002. For the period 2010 to 2020, it is assumed that the increases in the annual-rate of generation efficiency and industrial energy efficiency deduced for the period 1999 to 2010 continue.

Energy efficiency standards for residential and commercial buildings — The measure has a technical effect that increases the energy efficiency of residential and commercial buildings. The AGO estimates that the measure will reduce total emissions by 1.6 Mt in

111 ABARE, *Australian Energy: Projections to 2019-20*, ABARE Research Report 01.11, Canberra, 2001, p.17.

2010. It is modelled as cost-neutral annual increases in the efficiency with which energy is used in buildings. For the period 2010 to 2020, it is assumed that the annual shifts deduced for the period 1999 to 2010 continue.

Energy performance codes and standards for domestic appliances and commercial and industrial equipment — The measure increased the effectiveness of existing energy labelling by developing minimum energy performance standards for a broad range of new appliances and equipment. The AGO estimates that the measure will reduce total emissions by 6.1 Mt in 2010. The measure is modelled as a combination of cost-neutral annual shifts in industry technologies and consumer tastes against the usage of electricity and gas. For the period 2010 to 2020, it is assumed that the annual shifts deduced for the period 1999 to 2020 continue.

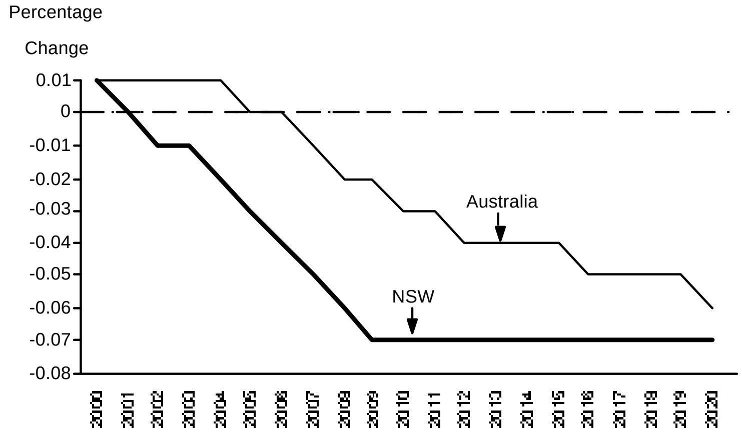
Energy efficiency best practice program — This measure encourages industries to become more efficient in the use of energy via innovative investments and changes in technologies. The AGO estimates that the measure will reduce total emissions by 1.5 Mt in 2020. It is modelled via cost-neutral annual shifts in industry technologies against the usage of electricity and gas. For the period 2010 to 2020, it is assumed that the annual shifts deduced for the period 1999 to 2020 continue.

Appendix E Scenario Two ¾ Baseline (with measures) Projection: Results

This appendix sets out detailed modelling results for Scenario Two.

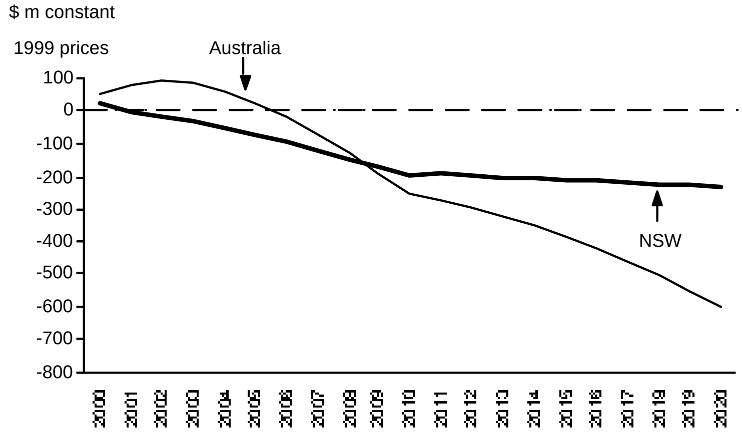
Figure E.1 shows the impact of the Baseline (with measures) Projection on Australian GDP and NSW GSP in terms of the percentage deviation from the Baseline (no measures) scenario. Figure E.2 shows the same information in dollar terms.

Figure E.1: Baseline (with measures) Scenario: Impact on GDP/GSP Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

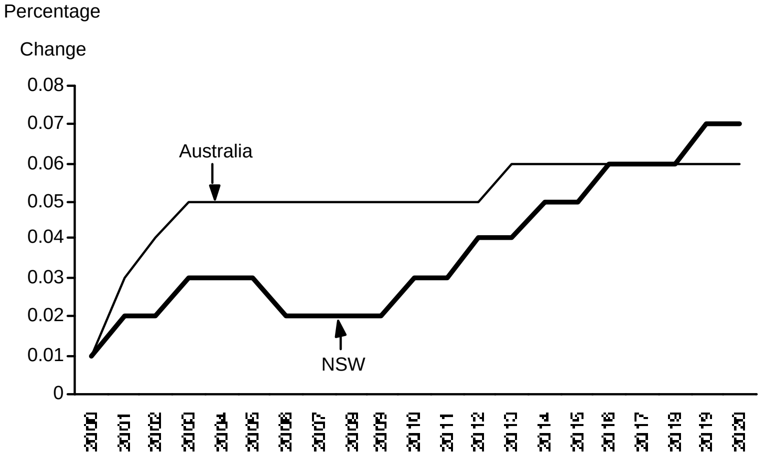
Figure E.2: Baseline (with measures) Scenario: Impact on GDP/GSP Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 ($m)



Source: MMRF-Green results

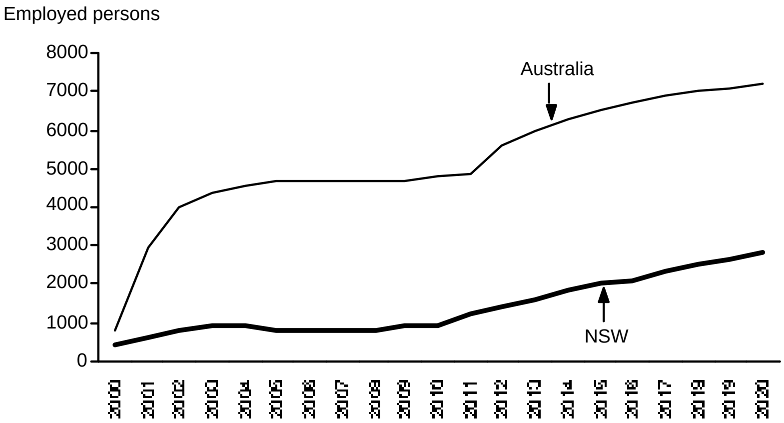
Figures E.3 and E.4 show the impact of Scenario Two on employment in terms of percentage deviation and persons employed, respectively, compared with Scenario One.

Figure E.3: Baseline (with measures) Scenario: Impact on Aggregate Employment Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure E.4: Baseline (with measures) Scenario: Impact on Aggregate Employment Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 (persons employed)



Source: MMRF-Green results

Table E.1 shows the impact of Scenario Two on the output of specific sectors in the electricity industry over the period 2000 to 2020 in percentage deviation terms.

Table E.1: Baseline (with measures) Scenario: Impact on NSW Electricity Industry Output Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 (percentage deviation)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2000	0.22	0.00	-0.44	0.00	0.50	-1.92	-1.92	-0.61	-1.32	0.21
2001	-1.29	0.00	-3.73	0.00	1.00	27.77	27.77	8.67	24.16	-0.86
2002	2.74	0.00	-5.60	0.00	1.50	60.14	60.12	17.56	51.68	-1.82
2003	-4.14	0.00	-6.74	0.00	2.01	94.42	94.39	26.13	81.12	-2.72
2004	-5.51	0.00	-7.53	0.00	2.51	130.58	130.54	34.56	113.00	-3.60
2005	-6.89	0.00	-8.13	0.00	3.03	168.60	168.55	42.94	147.71	-4.46
2006	-8.25	0.00	-8.63	0.00	3.54	208.51	208.44	51.34	185.61	-5.32
2007	-9.61	0.00	-9.07	0.00	4.05	250.32	250.25	59.82	227.08	-6.18
2008	-10.97	0.00	-9.46	0.00	4.57	294.10	294.02	68.40	272.48	-7.02
2009	-12.32	0.00	-9.82	0.00	5.09	339.92	339.83	77.11	322.21	-7.86
2010	-13.67	0.00	-10.19	0.00	5.62	387.90	387.80	85.99	376.72	-8.68
2011	-14.41	0.00	-9.52	0.00	6.14	411.95	411.85	92.16	412.65	-9.19
2012	-15.26	0.00	-9.48	0.00	6.67	435.65	435.57	98.34	450.11	-9.83
2013	-16.16	0.00	-9.75	0.00	7.20	459.20	459.14	104.55	489.20	-10.51
2014	-17.09	0.00	-10.20	0.00	7.74	482.69	482.65	110.79	529.99	-11.22
2015	-18.02	0.00	-10.76	0.00	8.27	506.22	506.19	117.08	572.58	-11.93
2016	-18.95	0.00	-11.41	0.00	8.81	529.85	529.84	123.43	617.09	-12.64
2017	-19.87	0.00	-12.17	0.00	9.35	553.66	553.68	129.84	663.63	-13.35
2018	-20.77	0.00	-13.06	0.00	9.90	577.73	577.78	136.33	712.33	-14.06
2019	-21.66	0.00	-14.09	0.00	10.45	602.13	602.21	142.90	763.35	-14.76
2020	-22.53	0.00	-15.29	0.00	11.00	626.94	627.05	149.57	816.83	-15.45

Source: MMRF-Green results

Table E.2: Baseline (with measures) Scenario: Impact on NSW Electricity Industry Employment Compared to the Baseline (no measures) Scenario ¾ 2000 to 2020 (persons employed '000)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2000	-0.04	0.00	-0.04	0.00	-0.02	-0.01	0.00	0.00	0.00	0.04
2001	-0.28	0.00	-0.13	0.00	0.29	0.20	0.08	0.03	0.00	0.02
2002	-0.35	0.00	-0.12	0.00	0.30	0.29	0.12	0.03	0.00	0.04
2003	-0.40	0.00	-0.12	0.00	0.30	0.37	0.15	0.03	0.00	0.05
2004	-0.46	0.00	-0.12	0.00	0.30	0.45	0.19	0.03	0.00	0.07
2005	-0.52	0.00	-0.12	0.00	0.30	0.54	0.22	0.03	0.01	0.08
2006	-0.58	0.00	-0.13	0.00	0.30	0.63	0.26	0.04	0.01	0.09
2007	-0.63	0.00	-0.13	0.00	0.30	0.73	0.30	0.04	0.01	0.10
2008	-0.69	0.00	-0.14	-0.01	0.30	0.82	0.34	0.04	0.01	0.10
2009	-0.74	0.00	-0.14	-0.01	0.30	0.92	0.38	0.04	0.01	0.10
2010	-0.79	0.00	-0.14	-0.01	0.30	1.02	0.42	0.04	0.01	0.10
2011	-0.74	0.00	-0.11	-0.01	0.20	0.89	0.37	0.03	0.01	0.04
2012	-0.79	0.00	-0.13	-0.01	0.19	0.92	0.38	0.04	0.01	-0.03
2013	-0.83	0.00	-0.14	-0.01	0.18	0.96	0.40	0.04	0.01	-0.09
2014	-0.86	0.00	-0.15	-0.01	0.17	0.99	0.41	0.04	0.01	-0.15
2015	-0.90	0.00	-0.16	-0.01	0.17	1.02	0.42	0.04	0.01	-0.21
2016	-0.93	0.00	-0.17	-0.01	0.16	1.05	0.44	0.04	0.01	-0.26
2017	-0.96	0.00	-0.17	-0.01	0.15	1.08	0.45	0.04	0.01	-0.31
2018	-0.98	0.00	-0.18	-0.01	0.15	1.11	0.46	0.04	0.01	-0.35
2019	-1.01	0.00	-0.19	-0.01	0.14	1.14	0.47	0.04	0.01	-0.39
2020	-1.03	0.00	-0.20	-0.01	0.14	1.17	0.48	0.04	0.01	-0.43

Source: MMRF-Green results

Table E.3 shows the impact of Scenario Two on electricity generation by fuel in terms of the percentage deviation in 2020 and in terms of petajules (PJ) of energy generated in both 2010 and 2020.

Table E.3: Baseline (with measures) Scenario: Impact on Electricity Generation by Fuel Compared to the Baseline (no measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Black coal	-22.5	-21.9
Brown coal	0.0	-19.6
Gas	-15.3	-8.9
Liquid fuel	0.0	0.0
• Hydro	11.0	-2.7
• Biomass	626.9	591.8
• Biogas	627.1	562.2
• Solar	149.6	142.0
• Wind	816.8	646.2
Total energy generated	**-16.8**	**-14.7**
Absolute deviation (PJ) — 2010		
Black coal	-42.5	-75.9
Brown coal	0.0	-25.7
Gas	-1.1	-1.7
Liquid fuel	0.0	0.0
• Hydro	1.4	-0.7
• Biomass	5.9	21.4
• Biogas	2.3	5.0
• Solar	0.5	0.8
• Wind	0.1	0.9
Total energy generated	**-33.3**	**-75.8**
Absolute deviation (PJ) — 2020		
Black coal	-89.5	-152.1
Brown coal	0.0	-58.9
Gas	-2.5	-15.6
Liquid fuel	0.0	0.0
• Hydro	3.0	-1.9
• Biomass	9.6	32.1
• Biogas	3.8	7.9
• Solar	0.9	1.3
• Wind	0.2	1.9
Total energy generated	**-74.6**	**-185.3**

Source: MMRF-Green results

Table E.4 shows the impact of Scenario Two on greenhouse gas emissions in 2010 and 2020.

Table E.4: Baseline (with measures) Scenario: Impact on Greenhouse Gas Emissions Compared to the Baseline (no measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Energy sector, total	-10.5	-10.1
• Fuel combustion	-11.0	-10.7
• Electricity	-26.2	-23.7
• Transport	0.0	0.0
• Other industries	0.1	0.1
• Household consumption	0.3	0.4
• Fugitive emissions from fuels	-1.4	-4.8
Industrial processes	0.1	0.3
Agriculture	0.0	0.0
Waste	0.1	0.0
LUCF	-0.1	0.0
Total	**-7.8**	**-7.6**
Absolute deviation (Mt CO2-e) — 2010		
Energy sector, total	-8.6	-27.3
• Fuel combustion	-8.5	-26.3
• Electricity	-8.5	-26.3
• Transport	0.0	0.0
• Other industries	0.0	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	-1.0
Industrial processes	0.0	0.0
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-8.6**	**-27.3**
Absolute deviation (Mt CO2-e) — 2020		
Energy sector, total	-15.4	-52.5
• Fuel combustion	-15.3	-50.2
• Electricity	-15.4	-50.4
• Transport	0.0	0.0
• Other industries	0.0	0.1
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	-0.1	-2.3
Industrial processes	0.0	0.1
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-15.4**	**-52.5**

Source: MMRF-Green results

Appendix F Scenario Three ¾ Demand Management: Assumptions and Model Shocks

Table F.1 sets out key assumptions in relation to the demand management measures used to determine the shocks to MMRF-Green.

Table F.1: Demand Management Measures: Key Assumptions

No	Plant	Potential Capacity (MW)	Lead Time (yrs)	Fixed Cost ($m/MW)	Capacity Factor (percent)	Life of Capital (yrs)	Marginal Generation Costs ($/MWh)	Energy Generation Potential (GWh pa)	Marginal Generation Costs ($m pa)
1	Comm-Industrial Energy Efficiency	100	1.5	1	40t	10	0	350	-
2	Comm-Industrial Standby Generation	100	0.5	0.05	1	15	750	9	7
3	Comm-Industrial Interruptibles	220	0.5	0.02	1	15	750	19	14
4	Commercial - Natural gas cooling	200	0.5	1.5	40	12	2	701	1
5	Residential Energy Efficiency	150	0.5	1	25	10	0	329	-
6	Residential hot water Electricity to gas	300	0.5	0.55	30	10	1	788	1

Source: SEDA Distributed Energy Solutions compendium

Table F.2 shows the capital costs for each of the demand management measures and the resulting shocks used to phase them in over a five-year period in MMRF-Green.

Table F.2: Demand Management Measures: Capital Cost ($m)

Measure	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1[a]	0	20	20	20	20	20
2	1	1	1	1	1	0
3	0.88	0.88	0.88	0.88	0.88	0
4	60	60	60	60	60	0
5	30	30	30	30	30	0
6	33	33	33	33	33	0
Total	124.88	144.88	144.88	144.88	144.9	20
Industry	61.88	81.88	81.88	81.88	81.88	20.00
Households	63.00	63.00	63.00	63.00	63.00	0.00

Note: While each measure is phased in over five years, the lead time for measure 1 is more than 12 months which delays its introduction until year two from the commencement of the demand management scenario

Table F.1 sets out the annual operating costs used to shock MMRF-Green under the Demand Management Scenario

Table F.3: Demand Management Measures: Operating Costs ($m)

Measure	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1.31	2.63	3.94	5.26	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57	6.57
3	0	2.89	5.78	8.67	11.56	14.45	14.45	14.45	14.45	14.45	14.45	14.45	14.45	14.45	14.45	14.45
4	0	0.28	0.56	0.84	1.12	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.54	1.68	1.82
5	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0.16	0.32	0.47	0.63	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.87	0.95	1.02	1.10
Total	**0**	**5**	**9**	**14**	**19**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**23**	**24**	**24**	**24**

Figure F.4 sets out the annual energy savings derived from the data and assumptions above.

Figure F.4: Demand Management Measures: Annual Energy Savings (GWh/pa)

Measure	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0	0	70	140	210	280	350	350	350	350	350	350	333	315	298	280
2	0	2	4	5	7	9	9	9	9	9	9	9	9	9	9	9
3	0	4	8	12	15	19	19	19	19	19	19	19	19	19	19	19
4	0	140	280	420	561	701	701	701	701	701	701	701	701	666	631	596
5	0	66	131	197	263	329	329	329	329	329	329	312	296	279	263	246
6	0	158	315	473	631	788	788	788	788	788	788	749	710	670	631	591
Total	0	369	808	1,248	1,687	2,126	2,196	2,196	2,196	2,196	2,196	2,140	2,067	1,959	1,850	1,742
Industry		146	362	577	793	1,009	1,079	1,079	1,079	1,079	1,079	1,079	1,062	1,009	957	904
H/holds		223	447	670	894	1,117	1,117	1,117	1,117	1,117	1,117	1,061	1,005	949	894	838

Figure F.5 sets out the estimated consumer cost savings derived from the energy consumption savings in Figure F.4 and used to shock MRF-Green.

Figure F.5: Demand Management Measures: Estimated Consumer Cost Savings ($m pa)

Measure	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16
1	0	0.0	4.8	9.5	14.3	19.1	23.9	23.9	23.9	23.9	23.9	23.9	22.7	21.5	20.3	19.1
2	0	0.5	1.5	3.0	5.1	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
3	0	3.1	6.2	9.2	12.3	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
4	0	13.8	27.6	41.4	18.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	65.7	62.5	59.3
5	0	7.2	14.3	21.5	28.6	35.8	35.8	35.8	35.8	35.8	35.8	34.0	32.2	30.4	28.6	26.8
6	0	8.0	16.1	24.1	32.1	40.1	40.1	40.1	40.1	40.1	40.1	38.2	36.3	34.4	32.5	30.6
Total	0.0	32.5	70.4	108.7	110.4	187.0	191.8	191.8	191.8	191.8	191.8	188.0	183.2	175.1	166.9	158.8
Industry		17.4	40.0	63.2	49.7	111.1	115.9	115.9	115.9	115.9	115.9	115.9	114.7	110.2	105.8	101.4
H/holds		15.2	30.4	45.6	60.7	75.9	75.9	75.9	75.9	75.9	75.9	72.2	68.5	64.8	61.1	57.5

Figure F.6 sets out the estimated network cost savings from the demand management measures used to shock MMRF-Green.

Figure F.6: Demand Management Measures: Estimated Network Cost Savings ($m pa)

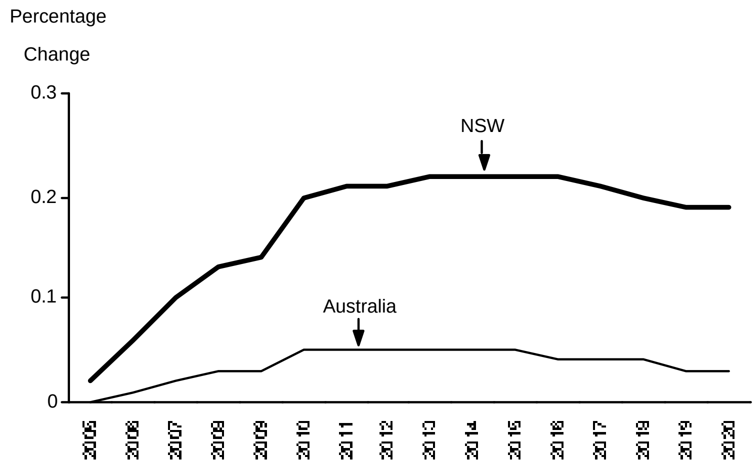
Measure	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15	Yr 16
1	0	2.5	5.1	7.6	10.2	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
2	0.0	2.5	5.1	7.6	10.2	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
3	0.0	5.6	11.2	16.8	22.4	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
4	0	5.1	10.2	15.3	20.4	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5
5	0	3.8	7.6	11.5	15.3	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1	19.1
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0.0**	**19.6**	**39.3**	**58.9**	**78.5**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**	**98.2**

Appendix G Scenario Three ¾ Demand Management Measures Scenario: Results

This appendix sets out detailed modelling results for Scenario Three.

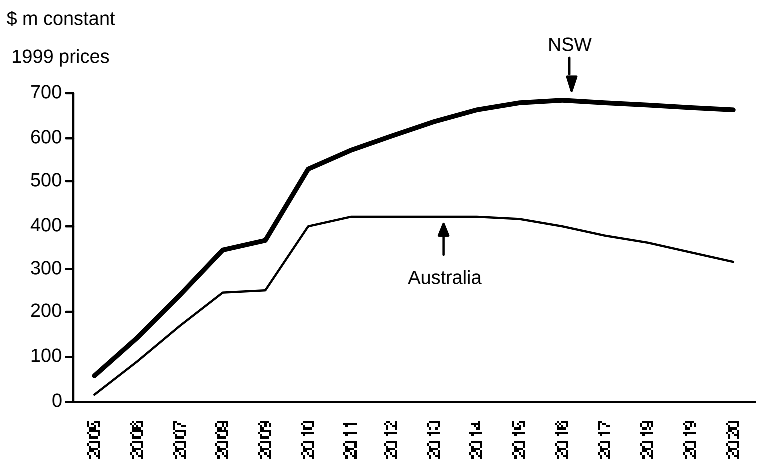
Figure G.1 shows the impact of the Baseline (with measures) Projection on Australian GDP and NSW GSP in terms of the percentage deviation from the Baseline (with measures) scenario. Figure G.2 shows the same information in dollar terms.

Figure G.1: Demand Management Measures Scenario: Impact on GDP/GSP Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure G.2: Demand Management Measures Scenario: Impact on GDP/GSP Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 ($m)

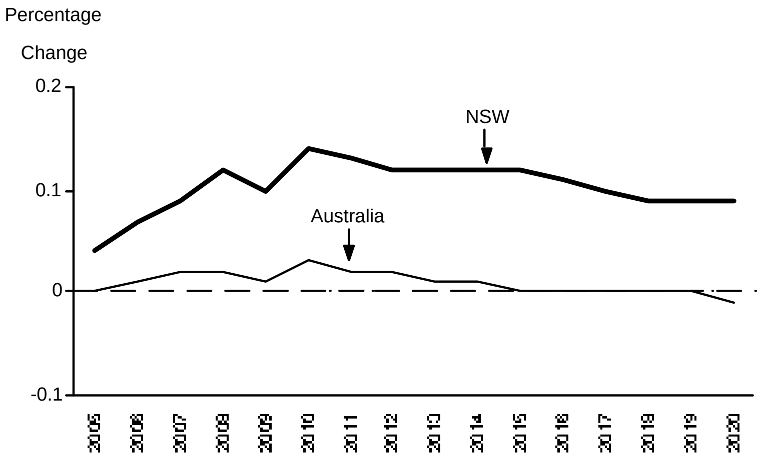


Source: MMRF-Green results

NSW GSP would be 0.2 percent or $240.8 million and 0.21 percent or $603.7 million higher than the ‘with measures’ baseline scenario in 2007 and 2012, respectively.

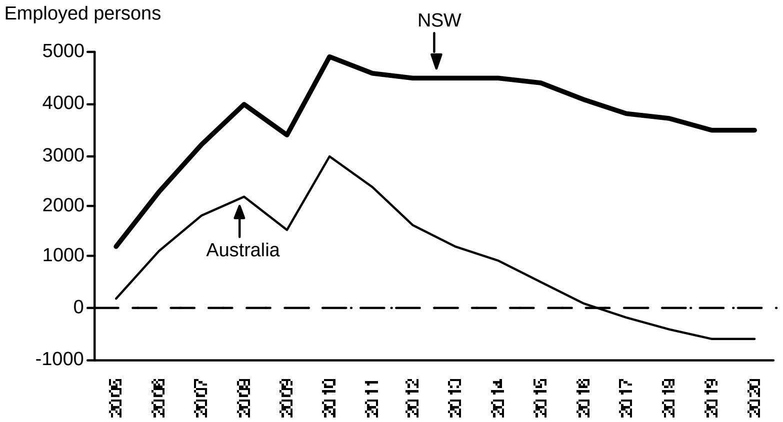
Figures G.3 and G.4 show the impact of Scenario Three on employment in terms of percentage deviation and persons employed, respectively, compared with Scenario Two.

Figure G.3: Demand Management Measures Scenario: Impact on Aggregate Employment Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure G.4: Demand Management Measures Scenario: Impact on Aggregate Employment Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (persons employed)



Source: MMRF-Green results

Employment in NSW would be 0.09 percent or 3,200 jobs and 0.12 percent or 4,500 jobs higher than the ‘with measures’ baseline scenario in 2007 and 2012, respectively.

Table G.1 shows the impact of Scenario Three on the output of specific sectors in the electricity industry over the period 2000 to 2020 in percentage deviation terms. Table G.2 sets out the impact of Scenario Three on employment in particular sectors of the electricity industry over the same period.

Table G.1: Demand Management Measures Scenario: Impact on NSW Electricity Industry Output compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	0.01	0.00	0.03	0.00	0.00	0.02	0.02	0.01	0.02	0.01
2006	0.09	0.00	0.20	0.00	0.00	0.13	0.13	0.04	0.13	0.09
2007	0.13	0.00	0.08	0.00	0.00	0.21	0.21	0.07	0.26	0.11
2008	0.11	0.00	-0.24	0.00	0.00	0.25	0.25	0.08	0.38	0.09
2009	0.27	0.00	0.18	0.00	0.00	0.37	0.37	0.12	0.49	0.25
2010	0.07	0.00	-1.00	0.00	0.00	0.24	0.24	0.09	0.53	0.02
2011	-0.06	0.00	-1.56	0.00	0.00	0.08	0.08	0.04	0.49	-0.12
2012	-0.18	0.00	-1.96	0.00	0.00	-0.08	-0.08	0.00	0.44	-0.25
2013	-0.32	0.00	-2.38	0.00	0.00	-0.27	-0.27	-0.06	0.34	-0.40
2014	-0.18	0.00	-2.80	0.00	0.00	-0.49	-0.49	-0.12	0.22	-0.56
2015	-0.62	0.00	-3.11	0.00	0.00	-0.70	-0.70	-0.18	0.10	-0.70
2016	-0.74	0.00	-3.23	0.00	0.00	-0.87	-0.87	-0.24	0.00	-0.81
2017	-0.81	0.00	-3.18	0.00	0.00	-0.99	-0.98	-0.28	-0.07	-0.87
2018	-0.86	0.00	-3.07	0.00	0.00	-1.07	-1.07	-0.31	-0.11	-0.91
2019	-0.89	0.00	-2.94	0.00	0.00	-1.14	-1.14	-0.34	-0.14	-0.93
2020	-0.92	0.00	-2.81	0.00	0.00	-1.19	-1.19	-0.36	-0.16	-0.95

Source: MMRF-Green results

Table G.2: Demand Management Measures Scenario: Impact on NSW Electricity Industry Employment compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (persons employed '000)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.44
2007	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.80
2008	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	-1.12
2009	0.04	0.00	0.02	0.00	0.01	0.01	0.00	0.00	0.00	-1.40
2010	-0.04	0.00	-0.07	0.00	-0.02	0.00	0.00	0.00	0.00	-1.73
2011	-0.03	0.00	-0.05	0.00	-0.01	0.00	0.00	0.00	0.00	-1.66
2012	-0.04	0.00	-0.04	0.00	-0.01	-0.01	0.00	0.00	0.00	-1.58
2013	-0.04	0.00	-0.05	0.00	-0.02	-0.01	0.00	0.00	0.00	-1.50
2014	-0.05	0.00	-0.05	0.00	-0.02	-0.02	-0.01	0.00	0.00	-1.42
2015	-0.06	0.00	-0.05	0.00	-0.02	-0.02	-0.01	0.00	0.00	-1.35
2016	-0.05	0.00	-0.04	0.00	-0.02	-0.02	-0.01	0.00	0.00	-1.27
2017	-0.04	0.00	-0.03	0.00	-0.01	-0.02	-0.01	0.00	0.00	-1.19
2018	-0.04	0.00	-0.02	0.00	-0.01	-0.02	-0.01	0.00	0.00	-1.12
2019	-0.03	0.00	-0.02	0.00	-0.01	-0.02	-0.01	0.00	0.00	-1.06
2020	-0.03	0.00	-0.02	0.00	-0.01	-0.02	-0.01	0.00	0.00	-1.01

Source: MMRF-Green results

Table G.3 shows the impact of Scenario Three on electricity generation by fuel in terms of the percentage deviation in 2020 and in terms of petajules (PJ) of energy generated in both 2010 and 2020.

Table G.3: Demand Management Measures Scenario: Impact on Electricity Generation by Fuel Compared to the Baseline (with measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Black coal	-0.9	-0.6
Brown coal	0.0	-0.2
Gas	-2.8	-0.3
Liquid fuel	0.0	0.0
• Hydro	0.0	0.0
• Biomass	-1.2	0.1
• Biogas	-1.2	-0.6
• Solar	-0.4	-0.2
• Wind	-0.2	0.8
Total energy generated	**-0.9**	**-0.4**
Absolute deviation (PJ) — 2010		
Black coal	0.2	-0.8
Brown coal	0.0	-0.6
Gas	-0.1	-0.3
Liquid fuel	0.0	0.0
• Hydro	0.0	0.0
• Biomass	0.0	0.0
• Biogas	0.0	0.0
• Solar	0.0	0.0
• Wind	0.0	0.0
Total energy generated	**0.1**	**-1.7**
Absolute deviation (PJ) — 2020		
Black coal	-2.9	-3.6
Brown coal	0.0	-0.5
Gas	-0.4	-0.5
Liquid fuel	0.0	0.0
• Hydro	0.0	0.0
• Biomass	-0.2	0.1
• Biogas	-0.1	-0.1
• Solar	0.0	0.0
• Wind	0.0	0.0
Total energy generated	**-3.6**	**-4.6**

Source: MMRF-Green results

Table G.4 shows the impact of Scenario Three on greenhouse gas emissions in 2010 and 2020.

Table G.4: Demand Management Measures Scenario: Impact on Greenhouse Gas Emissions Compared to the Baseline (with measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Energy sector, total	-0.2	-0.1
• Fuel combustion	-0.2	-0.1
• Electricity	-0.9	-0.4
• Transport	0.2	0.0
• Other industries	0.4	0.0
• Household consumption	0.1	0.0
• Fugitive emissions from fuels	0.4	0.0
Industrial processes	0.8	0.0
Agriculture	0.2	0.0
Waste	0.1	0.1
LUCF	0.1	0.0
Total	**-0.1**	**-0.1**
Absolute deviation (Mt CO2-e) — 2010		
Energy sector, total	0.2	-0.3
• Fuel combustion	0.2	-0.3
• Electricity	0.0	-0.4
• Transport	0.0	0.0
• Other industries	0.1	0.1
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	0.0
Industrial processes	0.0	0.0
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**0.2**	**-0.3**
Absolute deviation (Mt CO2-e) — 2020		
Energy sector, total	-0.2	-0.7
• Fuel combustion	-0.3	-0.7
• Electricity	-0.5	-0.8
• Transport	0.1	0.0
• Other industries	0.2	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	0.0
Industrial processes	0.0	0.0
Agriculture	0.1	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-0.1**	**-0.6**

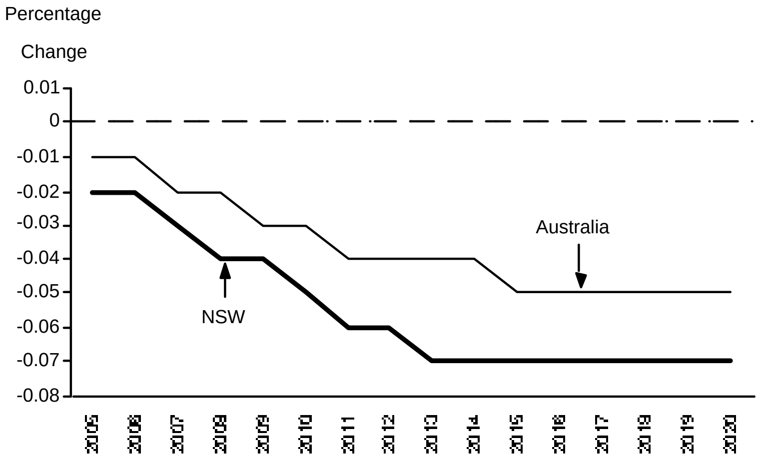
Source: MMRF-Green results

Appendix H Scenario Four ¾ Extended MRET: Results

This appendix sets out detailed modelling results for Scenario Four.

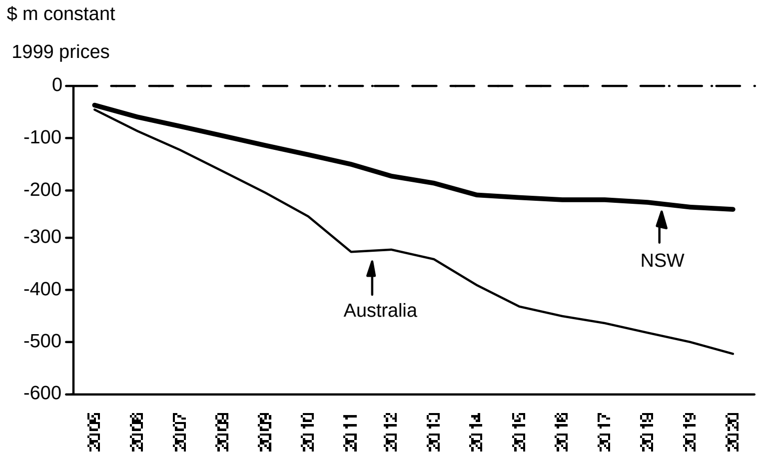
Figure H.1 shows the impact of the Extended MRET Scenario on Australian GDP and NSW GSP in terms of the percentage deviation from the Baseline (no measures) scenario. Figure H.2 shows the same information in dollar terms.

Figure H.1: Extended MRET Scenario: Impact on GDP/GSP Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure H.2: Extended MRET Scenario: Impact on GDP/GSP Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 ($m)

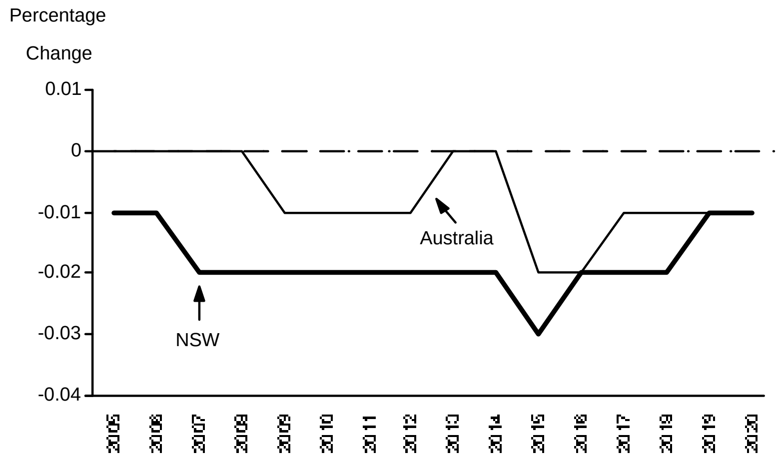


Source: MMRF-Green results

NSW GSP would be 0.03 percent or $78.4 million and 0.06 percent or $173.9 million lower than the 'with measures' baseline scenario in 2007 and 2012, respectively.

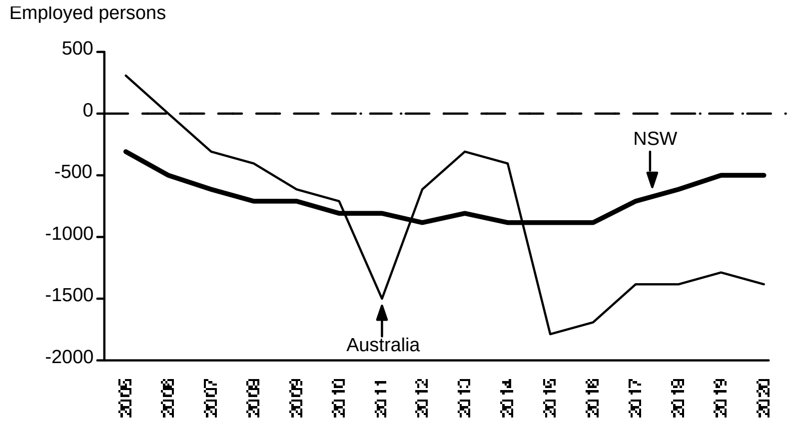
Figures H.3 and H.4 show the impact of Scenario Four on employment in terms of percentage deviation and persons employed, respectively, compared with Scenario Two.

Figure H.3: Extended MRET Scenario: Impact on Aggregate Employment Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure H.4: Extended MRET Scenario: Impact on Aggregate Employment Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (persons employed)



Source: MMRF-Green results

Employment in NSW would be 0.02 percent or 600 jobs and 0.02 percent or 900 jobs lower than the 'with measures' baseline scenario in 2007 and 2012, respectively.

Table H.1 shows the impact of Scenario Four on the output of specific sectors in the electricity industry over the period 2000 to 2020 in percentage deviation terms. Table H.2

sets out the impact of Scenario Four on employment in particular sectors of the electricity industry over the same period

Table H.1: Extended MRET Scenario: Impact on NSW Electricity Industry Output Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (percentage deviation)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	-0.52	0.00	-0.93	0.00	0.00	9.63	9.62	3.20	13.28	-0.25
2006	-0.89	0.00	-1.29	0.00	0.00	17.88	17.88	5.84	24.99	-0.34
2007	-1.21	0.00	-1.51	0.00	0.00	25.02	25.02	8.10	35.43	-0.38
2008	-1.52	0.00	-1.76	0.00	0.00	31.39	31.39	10.12	45.01	-0.41
2009	-1.83	0.00	-2.07	0.00	0.00	37.21	37.21	11.98	54.02	-0.43
2010	-2.16	0.00	-2.45	0.00	0.00	42.62	42.62	13.73	62.67	-0.45
2011	-2.54	0.00	-2.96	0.00	0.00	50.10	50.09	15.99	74.53	-0.48
2012	-2.93	0.00	-3.49	0.00	0.00	56.94	56.94	18.09	85.72	-0.53
2013	-3.31	0.00	-3.98	0.00	0.00	64.32	63.41	20.10	96.61	-0.57
2014	-3.70	0.00	-4.47	0.00	0.00	69.75	69.74	22.08	107.57	-0.60
2015	-3.76	0.00	-4.12	0.00	0.00	70.43	70.42	22.87	108.50	-0.51
2016	-3.83	0.00	-3.99	0.00	0.00	70.72	70.71	23.59	108.84	-0.46
2017	-3.92	0.00	-4.02	0.00	0.00	70.83	70.83	24.27	108.97	-0.43
2018	-4.02	0.00	-4.15	0.00	0.00	70.85	70.84	24.93	109.01	-0.42
2019	-4.13	0.00	-4.34	0.00	0.00	70.80	70.79	25.58	108.99	-0.42
2020	-4.24	0.00	-4.56	0.00	0.00	70.70	70.70	26.22	108.95	-0.43

Source: MMRF-Green results

Table H.2: Extended MRET Scenario: Impact on NSW Electricity Industry Employment Compared to the Baseline (with measures) Scenario ¾ 2000 to 2020 (persons employed, 000)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	-0.09	0.00	-0.04	0.00	0.12	0.26	0.11	0.02	0.01	0.08
2006	-0.08	0.00	-0.02	0.00	0.11	0.32	0.13	0.02	0.01	0.17
2007	-0.09	0.00	-0.02	0.00	0.09	0.38	0.16	0.02	0.01	0.26
2008	-0.10	0.00	-0.03	0.00	0.08	0.46	0.19	0.02	0.01	0.35
2009	-0.12	0.00	-0.03	0.00	0.08	0.55	0.23	0.02	0.01	0.42
2010	-0.13	0.00	-0.04	0.00	0.07	0.66	0.27	0.02	0.01	0.50
2011	-0.16	0.00	-0.05	0.00	0.09	0.77	0.32	0.02	0.01	0.57
2012	-0.18	0.00	-0.06	0.00	0.08	0.87	0.36	0.02	0.01	0.62
2013	-0.19	0.00	-0.06	0.00	0.07	0.99	0.41	0.02	0.02	0.67
2014	-0.21	0.00	-0.07	0.00	0.07	1.12	0.46	0.03	0.02	0.73
2015	-0.15	0.00	-0.02	0.00	0.03	0.93	0.39	0.02	0.02	0.68
2016	-0.15	0.00	-0.03	0.00	0.02	0.96	0.40	0.02	0.02	0.67
2017	-0.16	0.00	-0.04	0.00	0.02	1.00	0.41	0.02	0.02	0.66
2018	-0.16	0.00	-0.05	0.00	0.02	1.04	0.43	0.02	0.02	0.67
2019	-0.16	0.00	-0.05	0.00	0.01	1.09	0.45	0.02	0.02	0.68
2020	-0.17	0.00	-0.06	0.00	0.01	1.13	0.47	0.02	0.02	0.69

Source: MMRF-Green results

Table H.3 shows the impact of Scenario Four on electricity generation by fuel in terms of the percentage deviation in 2020 and in terms of petajules (PJ) of energy generated in both 2010 and 2020.

Table H.3: Extended MRET Scenario: Impact on Electricity Generation by Fuel Compared to the Baseline (with measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Black coal	-4.2	-5.4
Brown coal	0.0	-2.8
Gas	-4.6	-0.5
Liquid fuel	0.0	0.0
• Hydro	0.0	-0.8
• Biomass	70.7	69.0
• Biogas	70.7	71.5
• Solar	26.2	25.8
• Wind	108.9	113.3
Total energy generated	**0.3**	**0.1**
Absolute deviation (PJ) — 2010		
Black coal	-5.7	-14.5
Brown coal	0.0	-3.8
Gas	-0.3	-0.5
Liquid fuel	0.0	0.0
• Hydro	0.0	-0.1
• Biomass	3.3	14.2
• Biogas	1.3	2.6
• Solar	0.1	0.2
• Wind	0.1	0.8
Total energy generated	**-1.1**	**-1.1**
Absolute deviation (PJ) — 2020		
Black coal	-13.3	-30.4
Brown coal	0.0	-7.7
Gas	-0.7	-1.0
Liquid fuel	0.0	0.0
• Hydro	0.0	-0.5
• Biomass	10.2	32.1
• Biogas	4.0	6.1
• Solar	0.4	0.6
• Wind	0.4	1.8
Total energy generated	**1.0**	**1.0**

Source: MMRF-Green results

Table H.4 shows the impact of Scenario Four on greenhouse gas emissions in 2010 and 2020.

Table H.4: Extended MRET Scenario: Impact on Greenhouse Gas Emissions Compared to the Baseline (with measures) Scenario

	NSW	AUS
Percentage deviation — 2020		
Energy sector, total	-1.5	-1.5
• Fuel combustion	-1.6	-1.6
• Electricity	-3.6	-3.5
• Transport	-0.1	-0.1
• Other industries	-0.1	-0.1
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	-0.3	-0.7
Industrial processes	-0.2	-0.1
Agriculture	-0.1	-0.1
Waste	-0.1	-0.1
LUCF	-0.1	0.0
Total	**-1.2**	**-1.2**
Absolute deviation (Mt CO2-e) — 2010		
Energy sector, total	-1.1	-4.4
• Fuel combustion	-1.1	-4.3
• Electricity	-1.1	-4.2
• Transport	0.0	0.0
• Other industries	0.0	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	-0.2
Industrial processes	0.0	0.0
Agriculture	0.0	-0.1
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-1.1**	**-4.5**
Absolute deviation (Mt CO2-e) — 2020		
Energy sector, total	-2.3	-7.9
• Fuel combustion	-2.2	-7.6
• Electricity	-2.1	-7.4
• Transport	0.0	-0.1
• Other industries	0.0	-0.1
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	-0.3
Industrial processes	0.0	0.0
Agriculture	-0.1	-0.1
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-2.3**	**-8.0**

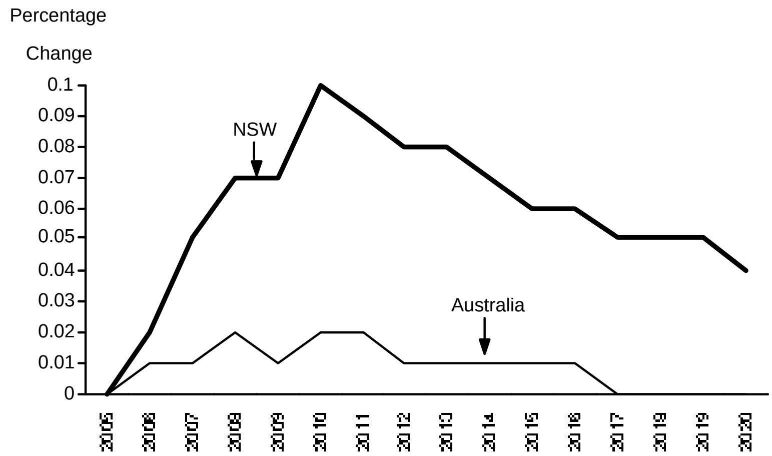
Source: MMRF-Green results

Appendix I Scenario Five ¾ SEI Development Fund

This appendix sets out detailed modelling results for Scenario Five.

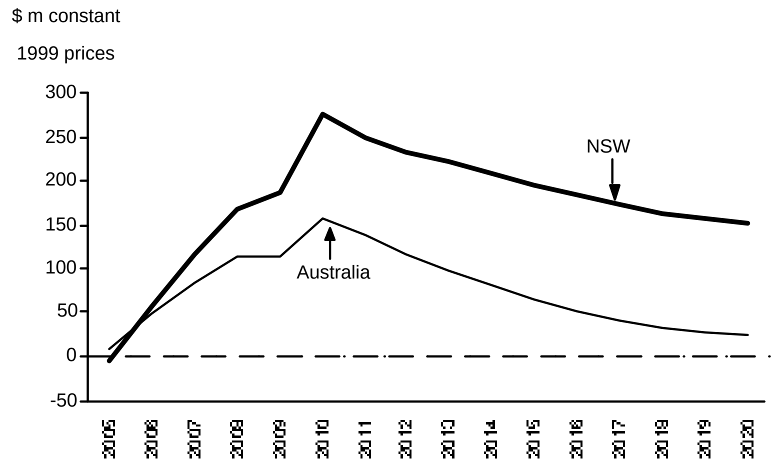
Figure I.1 shows the impact of the SEI Development Fund Scenario on Australian GDP and NSW GSP in terms of the percentage deviation from a baseline scenario that includes the cumulative impact of scenarios two, three and four. Figure I.2 shows the same information in dollar terms.

Figure I.1: SEI Development Fund Scenario: Impact on GDP/GSP ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure I.2: SEI Development Fund Scenario: Impact on GDP/GSP ¾ 2000 to 2020 ($m)

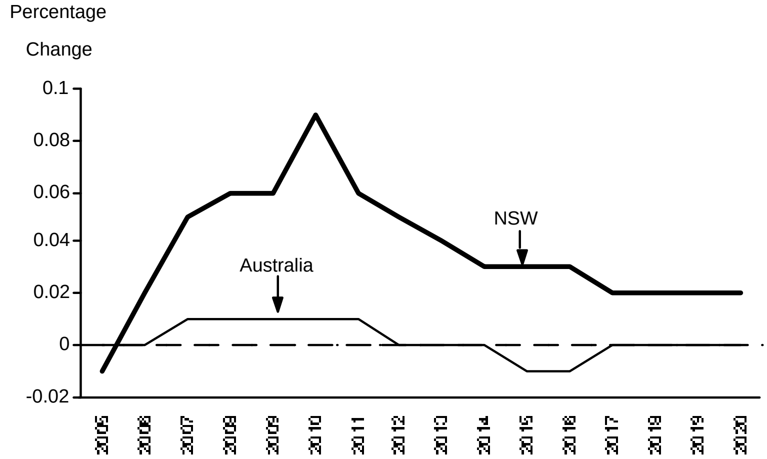


Source: MMRF-Green results

NSW GSP would be 0.05 percent or $115.6 million and 0.08 percent or $233.8 million higher than the 'with measures' baseline scenario in 2007 and 2012, respectively.

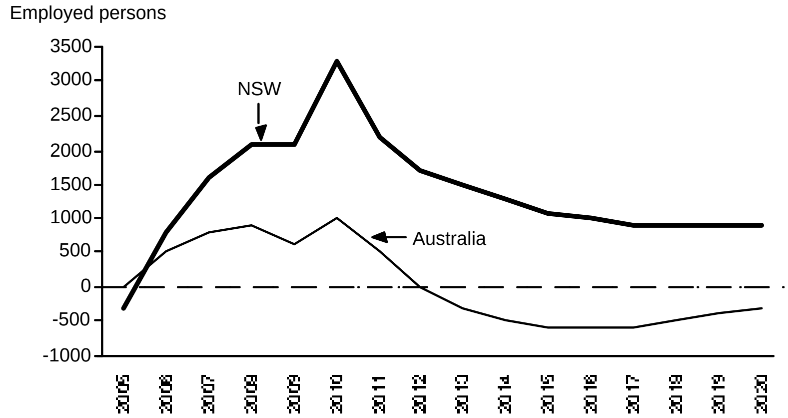
Figures I.3 and I.4 show the impact of Scenario Five on employment in terms of percentage deviation and persons employed, respectively.

FigureI.3: SEI Development Fund Scenario: Impact on Aggregate Employment ¾ 2000 to 2020 (percentage deviation)



Source: MMRF-Green results

Figure I.4: SEI Development Fund Scenario: Impact on Aggregate Employment ¾ 2000 to 2020 (persons employed)



Source: MMRF-Green results

Employment in NSW would be 0.05 percent or 1,600 jobs and 0.05 percent or 1,700 jobs higher than the 'with measures' baseline scenario in 2007 and 2012, respectively.

Table I.1 shows the impact of Scenario Five on the output of specific sectors in the electricity industry over the period 2000 to 2020 in percentage deviation terms. Table I.2 sets out the impact of Scenario Five on employment in particular sectors of the electricity industry over the same period

Table I.1: SEI Development Fund Scenario: Impact on NSW Electricity Industry Output ¾ 2000 to 2020 (percentage deviation)

Year	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	0.00	0.00	-0.02	0.00	0.00	-0.01	-0.01	0.00	-0.01	0.00
2006	-0.01	0.00	-0.23	0.00	0.00	5.03	5.37	5.24	9.64	0.13
2007	-0.10	0.00	-0.70	0.00	0.00	9.70	10.27	10.08	17.64	0.20
2008	-0.24	0.00	-1.25	0.00	0.00	13.24	13.96	14.22	23.37	0.21
2009	-0.33	0.00	-1.51	0.00	0.00	15.77	16.61	17.69	27.12	0.25
2010	-0.56	0.00	-2.24	0.00	0.00	17.37	18.28	20.52	29.28	0.13
2011	-0.70	0.00	-2.41	0.00	0.00	15.55	16.32	18.86	25.33	-0.04
2012	-0.79	0.00	-2.39	0.00	0.00	14.10	14.79	17.41	22.71	-0.15
2013	-0.86	0.00	-2.29	0.00	0.00	12.75	13.37	16.06	20.25	-0.24
2014	-0.91	0.00	-2.13	0.00	0.00	11.50	12.06	14.82	17.95	-0.30
2015	-0.93	0.00	-1.92	0.00	0.00	10.36	10.86	13.67	15.83	-0.35
2016	-0.93	0.00	-1.68	0.00	0.00	9.33	9.79	12.62	13.91	-0.37
2017	-0.93	0.00	-1.45	0.00	0.00	8.40	8.81	11.65	12.18	-0.38
2018	-0.92	0.00	-1.24	0.00	0.00	7.56	7.94	10.75	10.63	-0.39
2019	-0.90	0.00	-1.06	0.00	0.00	6.81	7.15	9.93	9.24	-0.40
2020	-0.89	0.00	-0.90	0.00	0.00	6.14	6.45	9.18	8.02	-0.40

Source: MMRF-Green results

Table I.2: SEI Development Fund Scenario: Impact on NSW Electricity Industry Employment ¾ 2000 to 2020 (persons employed '000)

	Black Coal	Brown Coal	Gas	Oil Prods	Hydro	Biomass	Biogas	Solar	Wind	Elec Supply
2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	0.00	0.00	-0.01	0.00	-0.03	0.00	0.00	0.00	0.00	-0.13
2007	-0.02	0.00	-0.02	0.00	-0.04	0.04	0.02	0.00	0.00	-0.25
2008	-0.03	0.00	-0.03	0.00	-0.04	0.09	0.04	0.01	0.00	-0.34
2009	-0.03	0.00	-0.02	0.00	-0.03	0.14	0.06	0.01	0.00	-0.42
2010	-0.07	0.00	-0.05	0.00	-0.04	0.18	0.08	0.01	0.00	-0.51
2011	-0.05	0.00	-0.03	0.00	-0.02	0.19	0.08	0.01	0.00	-0.45
2012	-0.05	0.00	-0.02	0.00	-0.01	0.19	0.08	0.01	0.00	-0.40
2013	-0.04	0.00	-0.02	0.00	-0.01	0.18	0.08	0.01	0.00	-0.36
2014	-0.04	0.00	-0.01	0.00	-0.01	0.18	0.08	0.01	0.00	-0.32
2015	-0.03	0.00	0.00	0.00	0.00	0.17	0.08	0.01	0.00	-0.29
2016	-0.03	0.00	0.00	0.00	0.00	0.17	0.07	0.01	0.00	-0.27
2017	-0.03	0.00	0.00	0.00	0.00	0.16	0.07	0.01	0.00	-0.26
2018	-0.02	0.00	0.00	0.00	0.00	0.16	0.07	0.01	0.00	-0.25
2019	-0.02	0.00	0.00	0.00	0.00	0.15	0.06	0.01	0.00	-0.24
2020	-0.02	0.00	0.00	0.00	0.00	0.14	0.06	0.01	0.00	-0.24

Source: MMRF-Green results

Table I.3 shows the impact of Scenario Five on electricity generation by fuel in terms of the percentage deviation in 2020 and in terms of petajules (PJ) of energy generated in both 2010 and 2020.

Table I.3: SEI Development Fund Scenario: Impact on Electricity Generation by Fuel

	NSW	AUS
Percentage deviation — 2020		
Black coal	-0.9	-0.4
Brown coal	0.0	0.2
Gas	-0.9	-0.1
Liquid fuel	0.0	0.0
• Hydro	0.0	0.1
• Biomass	6.1	-0.8
• Biogas	6.4	2.9
• Solar	9.2	5.6
• Wind	8.0	-3.5
Total energy generated	**-0.4**	**-0.2**
Absolute deviation (PJ) — 2010		
Black coal	-1.5	-0.8
Brown coal	0.0	0.3
Gas	-0.2	-0.3
Liquid fuel	0.0	0.0
• Hydro	0.0	0.0
• Biomass	1.3	-0.5
• Biogas	0.6	0.3
• Solar	0.2	0.2
• Wind	0.0	-0.1
Total energy generated	**0.5**	**-0.8**
Absolute deviation (PJ) — 2020		
Black coal	-2.8	-2.2
Brown coal	0.0	0.4
Gas	-0.1	-0.2
Liquid fuel	0.0	0.0
• Hydro	0.0	0.1
• Biomass	0.9	-0.4
• Biogas	0.4	0.2
• Solar	0.1	0.1
• Wind	0.0	-0.1
Total energy generated	**-1.5**	**-2.0**

Source: MMRF-Green results

Table I.4 shows the impact of Scenario Five on greenhouse gas emissions in 2010 and 2020.

Table I.4: SEI Development Fund Scenario: Impact on Greenhouse Gas Emissions

	NSW	AUS
Percentage deviation — 2020		
Energy sector, total	-0.3	0.0
• Fuel combustion	-0.3	0.0
• Electricity	-0.8	-0.1
• Transport	0.1	0.0
• Other industries	0.1	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.1	0.0
Industrial processes	0.1	0.0
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-0.2**	**0.0**
Absolute deviation (Mt CO2-e) — 2010		
Energy sector, total	-0.2	0.0
• Fuel combustion	-0.2	0.0
• Electricity	-0.3	-0.1
• Transport	0.0	0.0
• Other industries	0.1	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	0.0
Industrial processes	0.0	0.0
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-0.2**	**0.0**
Absolute deviation (Mt CO2-e) — 2020		
Energy sector, total	-0.4	-0.2
• Fuel combustion	-0.4	-0.2
• Electricity	-0.4	-0.2
• Transport	0.0	0.0
• Other industries	0.0	0.0
• Household consumption	0.0	0.0
• Fugitive emissions from fuels	0.0	0.0
Industrial processes	0.0	0.0
Agriculture	0.0	0.0
Waste	0.0	0.0
LUCF	0.0	0.0
Total	**-0.4**	**-0.2**

Source: MMRF-Green results

Appendix J Regional Impacts

Table J.1 shows the regional impact of Scenario Three.

Table J.1: Scenario Three ¾ Output and Employment for Sub-state Regions in NSW (absolute deviations from baseline (no measures) scenario)

	2005	2010	2015	2020	Ave 2005-2020
Gross Regional Product ($m)					
Sydney	36.2	276.1	395.0	409.3	249.3
Hunter	3.7	35.3	48.8	49.0	36.3
Illawarra	2.7	24.3	33.4	33.4	24.9
Richmond-Tweed	1.3	9.7	12.8	12.6	9.7
Mid-North Coast	1.7	11.9	14.7	13.9	11.4
Northern	0.7	8.7	12.2	12.4	9.0
North Western	0.5	5.8	8.1	8.4	6.0
Central West	0.9	9.5	13.0	13.1	9.7
South Eastern	1.2	9.4	12.6	12.6	9.6
Murrumbidgee	0.7	8.1	11.3	11.3	8.4
Murray	0.5	6.2	8.8	8.9	6.5
Far West	0.1	1.1	1.4	1.3	1.1
Employment ('000)					
Sydney	0.9	3.8	3.3	2.5	2.83
Hunter	0.1	0.4	0.3	0.3	0.28
Illawarra	0.1	0.3	0.3	0.2	0.23
Richmond-Tweed	0.0	0.1	0.1	0.1	0.09
Mid-North Coast	0.0	0.1	0.1	0.1	0.09
Northern	0.0	0.1	0.1	0.1	0.09
North Western	0.0	0.1	0.1	0.1	0.08
Central West	0.0	0.1	0.1	0.1	0.08
South Eastern	0.0	0.1	0.1	0.1	0.09
Murrumbidgee	0.0	0.1	0.1	0.1	0.08
Murray	0.0	0.1	0.1	0.1	0.08
Far West	0.0	0.0	0.0	0.0	0.0

Source: MMRF-Green results

Table J.2 shows the regional impact of Scenario Four.

Table J.2: Scenario Four ¾ Output and Employment for Sub-state Regions in NSW (absolute deviations from baseline (no measures) scenario)

	2005	2010	2015	2020	Ave 2005-2020
Gross Regional Product ($m)					
Sydney	-29.2	-123.7	-224.0	-276.1	-160.7
Hunter	-4.1	-15.1	-25.7	-30.6	-19.5
Illawarra	-2.0	-5.5	-7.5	-7.8	-6.1
Richmond-Tweed	-0.9	-2.8	-4.2	-4.4	-3.3
Mid-North Coast	-0.6	2.0	7.7	12.4	5.1
Northern	-0.9	-1.7	-1.0	0.2	-1.1
North Western	-0.6	-2.0	-2.8	-2.8	-2.2
Central West	-1.3	-5.0	-8.6	-9.8	-6.4
South Eastern	-0.4	0.9	4.2	7.3	2.8
Murrumbidgee	-0.8	-1.5	-0.7	0.5	-0.8
Murray	-0.6	-1.2	-0.9	-0.2	-0.9
Far West	-0.2	-0.6	-1.0	-1.2	-0.7
Employment ('000)					
Sydney	-0.5	-1.3	-1.7	-1.6	-1.34
Hunter	0.0	-0.1	-0.1	-0.1	-0.09
Illawarra	0.0	-0.1	-0.1	0.0	-0.06
Richmond-Tweed	0.0	0.0	0.0	0.0	0.0
Mid-North Coast	0.0	0.0	0.0	0.1	0.04
Northern	0.0	0.0	0.0	0.0	0.0
North Western	0.0	0.0	0.0	0.0	0.0
Central West	0.0	0.0	0.0	0.0	-0.01
South Eastern	0.1	0.1	0.0	0.0	0.06
Murrumbidgee	0.0	0.0	0.0	0.0	0.0
Murray	0.0	0.0	0.0	0.0	0.0
Far West	0.0	0.0	0.0	0.0	0.0

Source: MMRF-Green results

Table J.3 shows the regional impact of Scenario Five.

Table J.3: Scenario Five ¾ Output and Employment for Sub-state Regions in NSW (absolute deviations from Scenarios 2, 3 + 4)

	2005	2010	2015	2020	Ave 2005-2020
Gross Regional Product ($m)					
Sydney	-3.9	129.8	98.7	76.8	83.5
Hunter	-0.1	18.4	12.2	8.4	11.0
Illawarra	0.0	13.6	9.8	7.4	8.6
Richmond-Tweed	-0.1	5.3	3.6	2.8	3.2
Mid-North Coast	-0.1	8.9	5.9	4.3	5.4
Northern	-0.1	5.6	4.1	3.2	3.6
North Western	0.0	3.3	2.5	1.9	2.1
Central West	0.0	7.0	4.9	3.7	4.4
South Eastern	-0.1	6.8	5.1	4.0	4.4
Murrumbidgee	-0.1	5.2	3.8	2.9	3.3
Murray	0.0	3.9	3.0	2.3	2.6
Far West	0.0	0.5	0.3	0.2	0.3
Employment (‘000)					
Sydney	-0.2	2.2	0.6	0.5	0.86
Hunter	0.0	0.3	0.1	0.0	0.11
Illawarra	0.0	0.2	0.1	0.0	0.09
Richmond-Tweed	0.0	0.1	0.0	0.0	0.03
Mid-North Coast	0.0	0.1	0.0	0.0	0.04
Northern	0.0	0.1	0.0	0.0	0.01
North Western	0.0	0.0	0.0	0.0	0.0
Central West	0.0	0.1	0.0	0.0	0.01
South Eastern	0.0	0.1	0.0	0.0	0.01
Murrumbidgee	0.0	0.1	0.0	0.0	0.01
Murray	0.0	0.1	0.0	0.0	0.01
Far West	0.0	0.0	0.0	0.0	0.0

Source: MMRF-Green results

Table J.4 shows a summary of all scenarios including the net impact of all three together.

Table J.4: Summary of Regional Impacts

	Scenario 3	Scenario 4	Scenario 5	Net Impact
Employment (‘000)				
Sydney	2,830	-1,340	860	2,350
Hunter	280	-90	110	300
Illawarra	230	-60	90	260
Richmond-Tweed	90	-	30	120
Mid-North Coast	90	40	40	170
Northern	90	-	10	100
North Western	80	-	-	80
Central West	80	-10	10	80
South Eastern	90	60	10	160
Murrumbidgee	80	-	10	90
Murray	80	-	10	90
Far West	-	-	-	-

Source: MMRF-Green results
Note: The symbol – means less than 5 jobs

Appendix K Distributed Energy Solutions Compendium

Table 1— Distributed Energy Solutions SEDA Assessment

No.	Plant	Fuel Type
Demand Management & Energy Efficiency		
1	Commercial-Industry Energy Efficiency (including improved air conditioning)	Energy Efficiency
2	Commercial-Industry Standby Generation	Peak Clipping
3	Commercial-Industry Interruptibles	Peak Clipping
4	Commercial – Natural gas cooling	Gas Substitution
5	Residential Energy Efficiency (including lighting)	Energy Efficiency
6	Displacement – Residential Hot Water, Electricity to Gas	Gas Substitution
Cogeneration & New Gas		
7	Industry – Small Cogeneration	Gas Cogeneration
8	Alise (Botany) Cogeneration	Gas Cogeneration
9	Sithe (Kurnell) Cogeneration	Gas Cogeneration
10	Illawarra Eco-energy Park Cogeneration	Gas Cogeneration
11	Wagga-Wagga Cogeneration	Gas Cogeneration
12	Duke/Pt Kembla Cogeneration	Gas Cogeneration
13	Mac Gen/Tomago Combined Cycle Gas Turbine	New Gas
Biomass Renewables		
14	Municipal Solid Waste Gasification	Renewable (Bioenergy)
15	Dry Agricultural/Forestry Waste (Biomass Dry)	Renewable (Bioenergy)
16	Food/Agriculture Wet Waste (Biomass Wet)	Renewable (Bioenergy)
17	Bagasse Cogeneration (Biomass Dry)	Renewable (Bioenergy)
18	Landfill Gas	Renewable (Bioenergy)
19	Sewage gas (Municipal water)	Renewable (Bioenergy)
Renewables		
20	Hydro (Large)	Renewable
21	Hydro (Small)	Renewable
22	Wind	Renewable
23	Solar PV (Grid Connection)	Renewable
24	Residential – Solar Hot Water	Renewable
25	Tidal & Wave	Renewable
26	Geothermal – Hot Dry Rock	Renewable
27	Geothermal – Aquifer	Renewable
28	Solar thermal	Renewable
29	PV & PV-hybrid Remote Area Power Supply	Renewable
30	Micro Hydro Remote Area Power Supply	Renewable
31	Wind & Wind-hybrid Remote Area Power Supply	Renewable
Coal Related Technologies		
32	Improved Power Station Efficiency	Power Station Efficiency
33	Mine Waste Gas in Power Stations	Mine Gas
34	Mine Waste Gas – Dedicated Engine	Mine Gas
35	Mine Waste Gas – Vent Air Technology	Mine Gas

Source: SEDA, *Distributed Energy Solutions, Cost & Capacity Estimates for Decentralised Options for Meeting Electricity Demand in NSW*, February 2002.

Appendix L Study Brief

Following is a copy of the brief for the study.

“The purpose of the Sustainable Energy Jobs Report ('the Report') is to be a forward-looking study, outlining possible scenarios for the Sustainable Energy Industry over the next decade. It will provide an indication of the potential to grow the industry in light of international trends, and estimate the resultant benefits in terms of employment, Gross State Product and value of exports. The Report will have regard for the development of the industry to date, as well as domestic and international drivers and trends, including:

- the United Nations Framework Convention on Climate Change and the Kyoto Protocol;
- global and regional growth in energy demand;
- approaches to promoting sustainable energy adopted by overseas governments (eg mandating the uptake of renewable energy via tax and planning laws) and the private sector (eg corporate emissions trading schemes);
- the Commonwealth Government's Mandatory Renewable Energy Target; and
- the NSW Government proposal to enforce greenhouse benchmarks applying to electricity retailers, etc.

In view of wind energy's significant potential, the Report will also include a wind energy manufacturing case study, addressing the issues outlined in Schedule 4. This case study will set out the information required by a company looking to establish a wind energy manufacturing plant in New South Wales, and will be appropriate for use as a stand-alone document.

Drawing on both local and international experience, the Report will outline strategies needed to create market conditions that are conducive to fostering the development of a local Sustainable Energy Industry. It will also outline the sorts of measures required to facilitate investment in response to such market conditions - for example, targeted funding, tax concessions, market transformation etc. In this way, the Report will:

- highlight the potential for the Sustainable Energy Industry to contribute to the NSW economy - in terms of employment opportunities, investment, and exports; and
- outline the strategies required to realize that potential.

You will provide a report that addresses the following issues:

1) You will review the Sustainable Energy Industry and identify key sustainable energy technologies and policies for further analysis as follows:

   a) Identify for focussed study at least 7 key sustainable energy technologies (for example photovoltaics, solar water heating, waste to energy, fuel cells, efficient lighting, high efficiency motors, generation from mine waste gas etc) that have both high growth potential and high emissions abatement potential.

b. Review the state of the SEI globally, including recent and forecast growth in demand for these key sustainable energy technologies. Identify major companies in the global SEI and outline relevant characteristics (area of expertise, location, domestic and global market share etc).

c. Use case studies of specific companies, industries and countries to illustrate Government policies and corporate strategies that have been effective in growing the SEI.

d. Review the information in SEDA's Distributed Energy Solutions compendium (February 2002, available at www.ipart.nsw.gov.au) to ensure that it provides a comprehensive and realistic basis for estimating growth potential in the SEI in NSW over the next 5 to 10 years.

You will recommend technologies/sectors to be considered, taking into account:

- the capacity for NSW to compete domestically and internationally in light of the state of development of relevant industries locally and internationally; and
- forecast demand for the technologies.

The choice of technologies/sectors will draw on SEDA's Distributed Energy Solutions compendium and will be agreed with input from a Panel of Experts (to be convened by you) and in discussion with SEDA and the Steering Committee (convened by SEDA to oversee preparation of the Report).

The Panel of Experts will provide input on the choice of technologies/sectors, demand forecasts and modelling assumptions via a Workshop, to be convened by you. Membership of the Panel will be agreed in discussion with SEDA and the Steering Committee.

2) You will assess the potential of the Sustainable Energy Industry to contribute to the NSW economy as follows:

- You will assess the potential to grow the SEI in NSW, taking account of existing market barriers, current policy drivers (including the Commonwealth Government's Mandatory Renewable Energy Target, the NSW Demand Management Code, the NSW Government proposal to enforce greenhouse benchmarks etc), the emerging tightening of the generation market and constraints in the networks.
- Your assessment will also have regard to possible Market Transformation activities to address market barriers, international trends and drivers (including growing support for the Kyoto Protocol, US proposals to reduce greenhouse emissions through tax incentives etc), corporate strategies to mitigate exposure to future carbon costs through internal emissions trading schemes and bilateral deals, regional and global growth in energy demand etc.
- You will examine the potential to develop the SEI in NSW in the key technologies/sectors identified in part 1 above. You will also provide an estimate of the resultant SEI employment potential - including in the areas of manufacturing, construction, installation, maintenance etc.
- The MONASH MMRF-GREEN model will be used to quantify the impact of the SEI on the State economy and budget in terms of Gross State Product, investment, jobs

etc, as well as greenhouse abatement outcomes. Inputs to the model will be agreed in consultation with SEDA and the Panel of Experts to be convened by you. The follow scenarios will be modelled:

- SCENARIO 1: base case (excluding MRET and SEDA initiatives);
- SCENARIO 2: existing measures (MRET, current level of SEDA initiatives);
- SCENARIO 3: announced measures (Mandatory Greenhouse Benchmarks, effective implementation of the Demand Management Code, impact of these on MRET investment)
- SCENARIO 4: proposed package of additional policies to encourage the NSW SEI.[112]

For the purpose of this Report, the following factors will be addressed in developing the model and/or the scenarios:

You will model demand management and energy efficiency as investment by industry sectors which shrinks demand for energy and creates knock-on equilibrating substitution effects. We note that the model does not differentiate between peak clipping technologies such as dispatchable standby generation and interruptible supply on the one hand and base load capacity such as energy efficiency on the other. You will address this simplification in the accompanying analysis, if it is considered to have a material impact on outcomes of the modelling.

- You will incorporate within the gas sector:
  - cogeneration (by increasing efficiency and/or factoring in both electricity and heat outputs); and
  - waste coal mine gas (with an adjustment to take account of avoided methane emissions). Links with the mining industry will be made where appropriate.
- You will incorporate a 'new' renewables sector as an industry sector (in addition to the 'old', hydro-dominated renewable sector) reflecting at least two (and possibly three, depending on data availability) subsets:
  - one will reflect lower capital cost/higher capacity factor renewables (eg bioenergy). Links with the agriculture industry will be made where appropriate.
  - the other will reflect higher capital cost/lower operating cost renewables (eg wind and, possibly, solar).
- Appropriate labour intensiveness factors will be incorporated to model employment outcomes.

112 During the course of the study, changes were made to the scenarios to be modelled using MMRF-Green by mutual agreement between SEDA and The Allen Consulting Group. The changes are reflected in the scenarios modelled in Chapter Eight.

- You will model the impact of the sustainable energy sector by, among other things, quantifying the reduction in demand for other generation, and quantifying the impact on manufacturing and services (including in relation to intermediate inputs).

- While the model does not accommodate a separate electricity network sector, you will reflect the (varying) benefits of embedded generation and demand management (in terms of avoided transmission and distribution costs) by adjusting inputs and/or network investments associated with particular technologies/sectors.

- The modelling and accompanying analysis will, where appropriate, identify and consider known institutional and market barriers to the efficient uptake of sustainable energy options.

- You will, as far as practical, factor in the operation of the National Electricity Market by including in the model (constrained) trade in energy between NEM states and non-NEM states (taking into account that Tasmania may join the NEM in the life time of the period modelled).

- The model is an open economy model and includes international trade and investment flows (so as to take account of import substitution etc).

- The model will include a limited (but reasonable) number of industry sectors, agreed in discussion with SEDA.

3) You will develop scenarios for the Sustainable Energy Industry of the future as follows:

Based on the above, you will identify strategic opportunities for NSW to grow the SEI in regions, including:

- Western Sydney;

- the Hunter;

- North Coast;

- Central West; and

- the Illawarra.

Analysis of the potential job growth opportunities in these regions will have regard for structural and employment characteristics of these regions, skill sets, re-training requirements etc.

Using the MONASH MMRF-GREEN model, you will quantify opportunities in terms of potential jobs, investment, Gross State Product, and greenhouse abatement outcomes by the years 2007 and 2012. Acknowledging that shifting to a more sustainable energy future will have varying impacts on energy users and industry, this analysis should quantify economic development, investment and job potential in net (rather than gross) terms. You will also estimate the associated greenhouse gas abatement and the value of customer energy savings achieved.

3a) Wind Manufacturing Case Study

You will include in the Report a case study addressing the issues outlined below. The case study will set out the information required by a company looking to establish a wind manufacturing plant in New South Wales, and will be appropriate for use as a stand-alone document.

The case study will address the following:

- Potential market for a manufacturing plant based in NSW (based on estimated domestic and international demand).
- The availability and characteristics of the workforce required (including skill sets and relative competitiveness, typical work practices, productivity figures, sub-contractor capabilities).
- The capital and operating costs of a plant (including costs relating to land, building, machinery, labour, taxes, transport and power costs, customs, duties and tariffs) and potential sources of finance.
- Potential competitiveness of a NSW wind manufacturer compared with other suppliers (expressed as a comparison of cost per unit and per MW of wind capacity, and including an assessment of relative costs, exchange rates etc).
- Infrastructure needed to support a wind manufacturing plant (including roads, inbound and outbound logistics, borders/customs, telecommunications, airports, sea ports, R&D facilities).
- Business climate facing potential investors (including business and sovereign risk, inflation, balance of trade, R&D expenditure, corporate credibility, Australia's international reputation).
- Identify potential locations in NSW for a manufacturing facility (eg Lithgow, Albury/Wagga Wagga, Illawarra, Newcastle, Western Sydney).
- Quantify the economic outcomes (jobs - including in manufacturing, construction, installation and maintenance etc; investment; GSP) and greenhouse gas abatement associated with a manufacturing capability (drawing on the modelling work outlined above).
- Strategies and policy initiatives needed to attract a facility (in terms of both strategies to grow demand for wind energy and strategies to facilitate market responses to that demand).

4) Outline strategies to realise the potential for job growth identified through the above process

You will identify key policy initiatives required to support the development of the SEI and, in particular, to help realise the scenarios outlined above. Strategies will address both the required market drivers and the measures required to facilitate market responses. In terms of market drivers, strategies might - for example - create demand for Sustainable Energy Industry products and services through energy policy, planning instruments, information, financial incentives etc. In terms of facilitating market responses, strategies might include targeted investment (eg Government funding, joint ventures, public private partnerships), financial incentives (tax concessions, seed funding etc), training/re-training programs etc.”

The brief also contained a detailed elaboration of part 3A, the wind manufacturing case study. The case study is published as a separate report.